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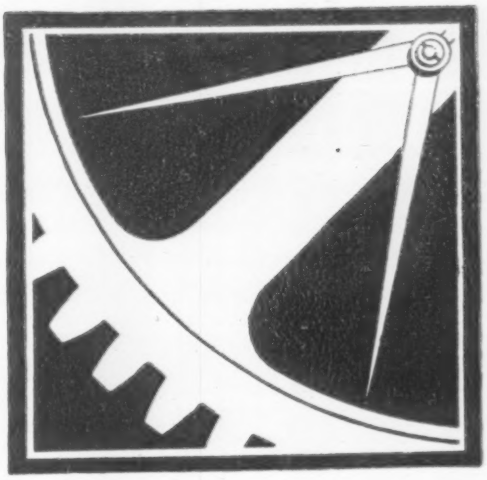
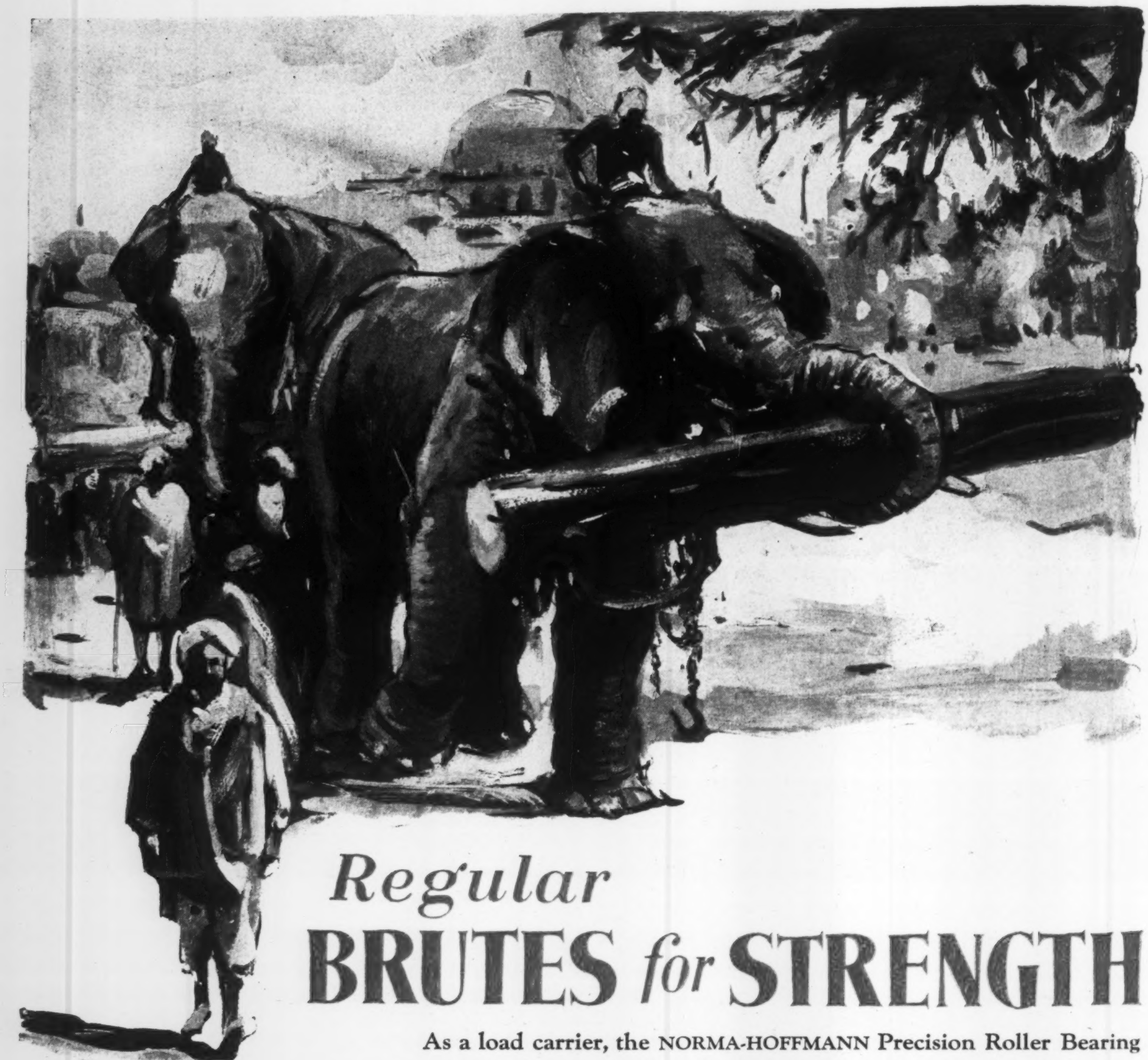
MACHINE DESIGN



AS IT AFFECTS

ENGINEERING–PRODUCTION–SALES



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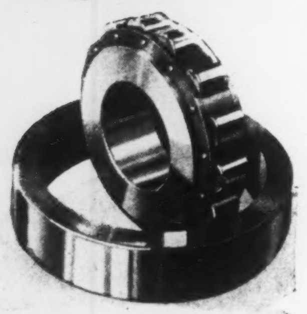

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MACHINE DESIGN

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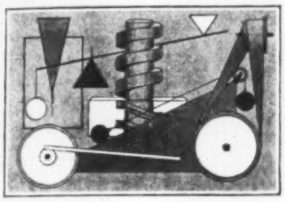
ENGINEERING-PRODUCTION-SALES

Volume 2 **September, 1930** **Number 9**



In This ISSUE

WITH the introduction recently of numerous new alloys, Machine Design *has felt it desirable to bring up-to-date its directory of iron, steel and nonferrous alloys which originally was published in the January, 1930, issue. The new directory is included as a loose insert in this number.*

The alloys have been listed alphabetically by trade names. Information covering uses and analyses of the various materials has been included wherever available. It is anticipated that the revised supplement will create even more interest than did the original edition and will assist greatly those engineers faced with problems connected with selection of materials.

L. E. Jermy

Managing Editor

CONTENTS

Page

Selection of Correct Materials Rests with Designer **23**
By Harold F. Shepherd

Scanning the Field for Ideas **28**

Correcting an Error in Application of Flexure Formula **32**
By Fred B. Seely

Lubrication of High Speed Spindles Is Major Feature **35**
By F. A. Firnhaber

Steel Forgings in Design **38**
By Lawford H. Fry

Simplifying Design Calculations by Use of Charts **42**
By H. M. Brayton

How Design Affects Sales **45**
By John D. Rauch

Meeting High Pressure Problems in Journal Bearings **46**

Preserving Valuable Drawings **49**
By E. L. Chevraux

Professional Viewpoints **51**

An Announcement (Editorial) **52**

Patrick Bell and the Reaper **53**
An Illustration by Schroeder

Noteworthy Patents **54**

Men of Machines **56**

Leaders in Design, Engineering and Research **57**

Topics of the Month **60**

New Materials and Parts **64**

How Is Business? **70**

Manufacturers' Publications **77**

Obituaries **78**

Business Announcements and Sales Briefs **80**

Calendar of Meetings and Expositions **20**

Directory of Iron, Steel and Nonferrous Alloys ...... **Loose Insert**

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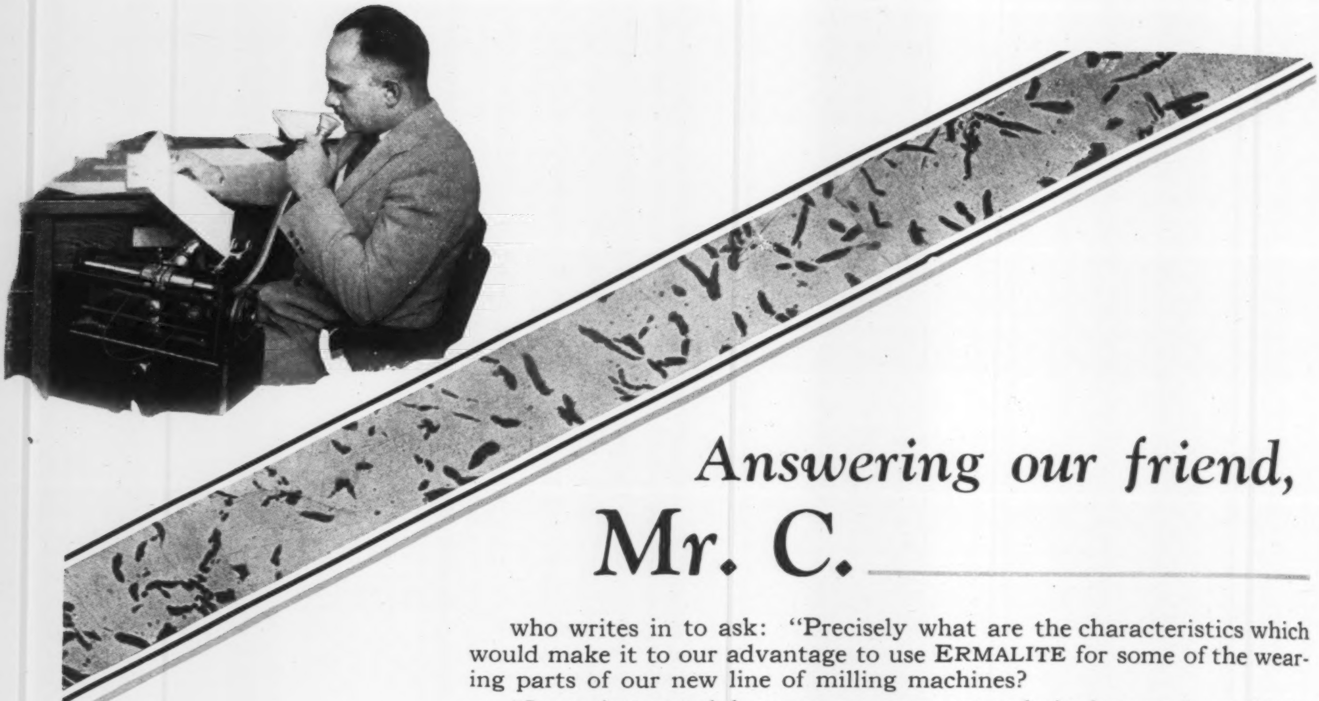


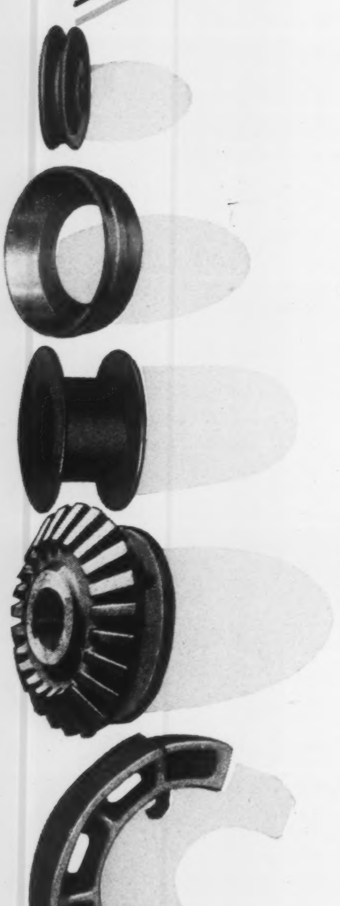
Answering our friend, Mr. C. ________

who writes in to ask: "Precisely what are the characteristics which would make it to our advantage to use ERMALITE for some of the wearing parts of our new line of milling machines?

"I am interested because we are now redesigning, and would be glad to secure lower cost on parts subject to high stresses and frictional wear."

There must be thousands of machine designers who, like Mr. C. ________, have heard of ERMALITE but do not yet fully realize its use and its economies.

For them, we are quoting here (in part) our reply to Mr. C. ________:



> "This alloyed material is cast in green sand molds; it has some of the desirable characteristics of gray iron, yet is far superior.
>
> "Physical properties: Tensile strength, 60,000 to 65,000 lbs. per square inch; only 1% to 2% elongation in 2 inches, yet a transverse strength of 5,500 to 6,500 lbs. on 1-inch round bar; 12-inch span with a total deflection of .35 inch to .45 inch at center. Brinell hardness as cast, 235 to 245, yet easily machined considering its density—for example, we are machining round castings of 16 inches to 20 inches diameter, 3/8-inch to 3/4-inch thick, at 150 to 180 peripheral feet.
>
> "ERMALITE has shown wearing qualities far superior to those of gray iron or steel—at far lower cost than steel. We are using it with great success in gears; for example, one ERMALITE gear on an industrial truck has shown more than 100% longer service than a steel gear it replaced, with considerably quieter operation.
>
> "It can be heat-treated and hardened to 500 Brinell, and drawn back to various hardnesses.
>
> "ERMALITE has a very dense grain structure, and has high resistance to hydraulic and air pressures. We have tested 1/4-inch to 5/16-inch wall thickness up to 3,000 lbs. pressure, without failure."

Where reasonable cost is important, and high tensile strength and wear-resistance are needed, this new alloyed material can serve you exceptionally well.

We shall be very glad to cooperate with any machine designer in making proper use of this low-cost alloyed material, for innumerable parts in which it will prove superior to steel, and effect a considerable saving. *Write us for details.*

ERIE MALLEABLE IRON COMPANY
Erie, Pa.

Ermalite

TRADE MARK
REGISTERED

222

Itemized Index, September, 1930

Key: Edit, Editorial Pages; Adv, Advertising Pages; R, Right hand column; L, Left hand column.

Compiled for the assistance of engineers confronted with specific design problems

Design Calculations:
- Moment of Inertia from Charts, Edit. 42, 43, 44
- Application of Flexure Formula, Edit. 32, 33, 34 L
- Equipment for, Adv. 82 L

Design Problems:
- High Pressure Bearings, Edit. 46, 47, 48
- Combating Corrosion, Edit. 26 R
- Eliminating Vibration, Edit. 36 L
- Lubricating Bearings, Edit. 35, 36, 37
- Sales of Product, Edit. 45
- Employment of Forgings, Edit. 38, 39, 40, 41
- Selecting Materials, Edit. 23, 24, 25, 26, 27, Loose Insert

Materials:
- Alloys (Iron), Adv. 6
- Aluminum, Edit. 24 L, 26 L, 27
- Babbitt, Edit. 27 R
- Composition, Edit. 37
- Rare Metals and Alloys, Adv. 74 L
- Steel (Carbon), Edit. 25 L
- Steel (Carbon Chromium), Edit. 25 R, 26 L, 27 L
- Steel (Chrome Nickel), Edit. 24 L, 26 L
- Steel (Cold Finished), Adv. 59
- Zinc, Adv. 85

Mechanisms:
- Free-Wheel, Edit. 28, 29

Organization and Equipment:
- Of Engineering Department, Edit. 49, 50; Adv. 18

Parts:
- Bearings, Edit. 34 R, 46, 47, 48; Adv. 2, 11, 22, 63, 75, 76, 78 L, 82 L, 84
- Cast Parts, Edit. 24 R; Adv. 9, 17
- Clutches, Adv. 61
- Controls (Electrical), Edit. 64, 66 L; Adv. 71, 73
- Cork, Adv. 19
- Couplings, Edit. 36 R
- Drives, Edit. 31, 54, 68 R, 72 R, 74 R; Adv. 3, 15, 65, 72 L, 83
- Fastenings, Adv. 14, 86
- Flexible Shafts, Adv. 13
- Forgings, Edit. 25 L, 38, 39, 40, 41
- Heating Units, Adv. 16
- Lubricating Equipment, Edit. 68 R; Adv. 8
- Motors, Edit. 31, 66 R, 68 L; Adv. 67, 79, 81
- Packing Glands and Packing, Edit. 37; Adv. 4, 10, 21
- Pumps, Edit. 66 L
- Stampings, Adv. 69
- Welded Parts, Adv. 12

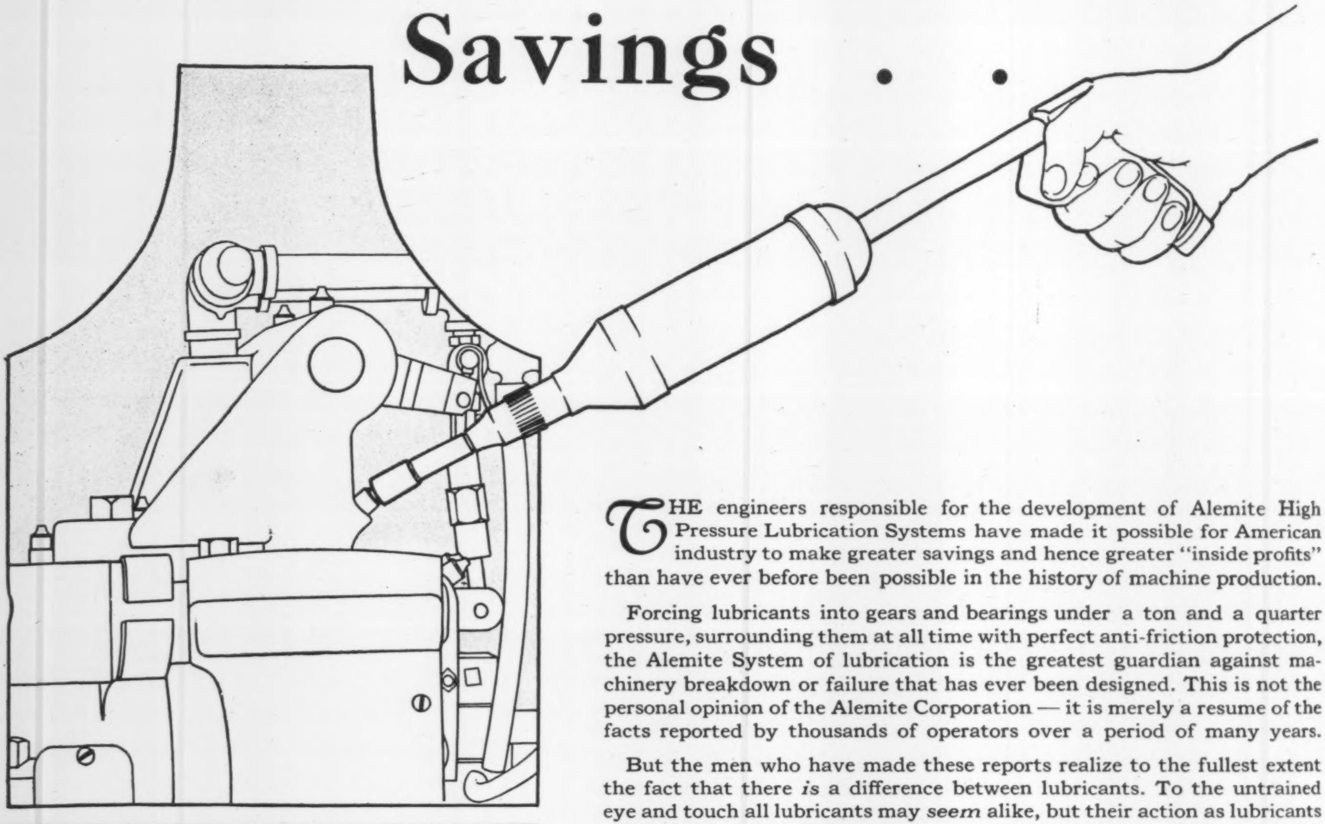
Principles:
- Hydraulic, Edit. 30

FOR those of our subscribers who keep a permanent file of Machine Design, a combined contents index, covering the twelve issues of the year is available each January for the asking. If you want a copy for your files, just notify the circulation department now to put your name on the list to receive one each year as it is published.

This year, in addition to the regular index, the issues of Machine Design from August to December will be covered by an Itemized Index combined for these months. This should prove of unusual value for reference purposes.

In this connection, you still can get a copy of the 1929 Contents Index if you'd like it.

Why Only Genuine Alemite Lubricants Can Accomplish These Genuine Savings . . .



THE engineers responsible for the development of Alemite High Pressure Lubrication Systems have made it possible for American industry to make greater savings and hence greater "inside profits" than have ever before been possible in the history of machine production.

Forcing lubricants into gears and bearings under a ton and a quarter pressure, surrounding them at all time with perfect anti-friction protection, the Alemite System of lubrication is the greatest guardian against machinery breakdown or failure that has ever been designed. This is not the personal opinion of the Alemite Corporation — it is merely a resume of the facts reported by thousands of operators over a period of many years.

But the men who have made these reports realize to the fullest extent the fact that there *is* a difference between lubricants. To the untrained eye and touch all lubricants may *seem* alike, but their action as lubricants is highly varied. Lubricants which corrode, rust, or become gummy in service are almost as bad as no lubricants at all. Their price is cheap but their results are most expensive.

It has been the duty of Alemite Corporation through many years, to develop specific lubricants for every mechanical operation. All of these are made to definite formulae, which never vary except to be improved. They are absolutely pure in form — non-acid, non-corrosive, never become gummy — and never fail to lubricate with the fullest protection possible.

The results from the use of such lubricants are so amazing as to demand proof from any engineer before they are believable. It is Alemite Corporation's urgent desire that you judge these performances solely upon the basis of your own findings in some establishment where you can check accurately under your own supervision.

Alemite Corporation does not ask you to believe that Alemite Fittings, together with Genuine Alemite Lubricants, can save their own cost and earn a dividend of 200% thereon from the very first year. Such a statement partakes of exaggeration. But it does ask you to believe your own findings, your own accurately checked records under full production load.

To the end that you may prove to yourself what Alemite High Pressure Systems used in connection with Genuine Alemite Lubricants can accomplish for you on the machinery you design and build, special cost sheets have been designed, which will be furnished you gratis. And a special consultation service is offered you absolutely without obligation and with no hope of accomplishing any other purpose than proving completely to yourself the enormous leaks in lubrication costs which you may put a stop to by following this modern, efficient program of lubrication.

Alemite Corporation (Division of Stewart-Warner), 2644 N. Crawford Avenue, Chicago.

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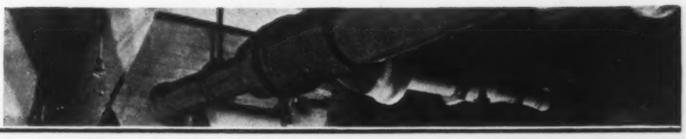
3. Saves 70% of Lubricating Time.
4. Saves 200% on Investment the First Year.
5. Saves in Belting and Other Materials.
6. Saves on Power by Reducing Friction to Minimum.
7. Saves on Cleaning Costs — No Leakage.

ALEMITE

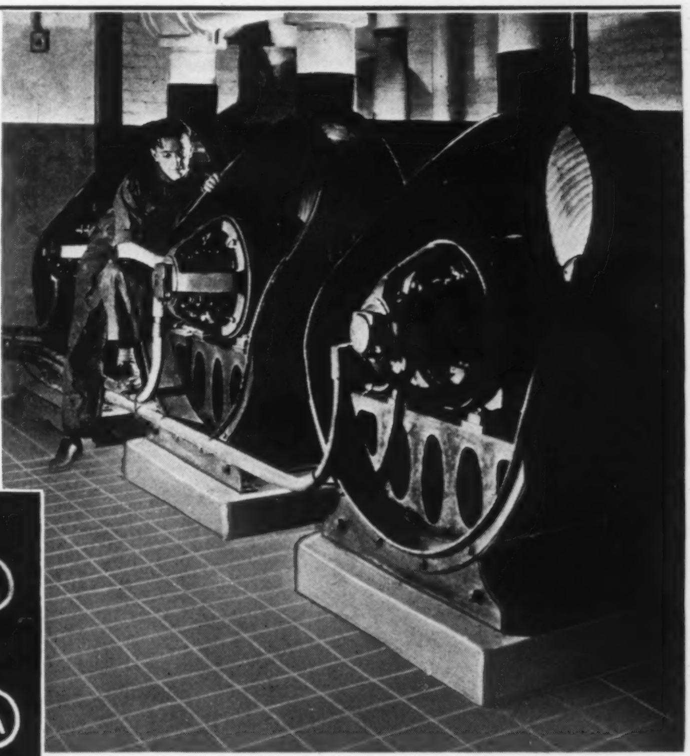
High Pressure Lubrication



A WRENCH WON'T STOP VIBRATION

so he calls on

CORK



Armstrong's Cork Machinery Isolation is installed under these machines in the Barclay-Vesey Telephone Building, New York Telephone Co., New York City.

You can't go wrong on Armstrong's Isolation: just watch for the Circle A.

THERE are certain things that can't be mended with tools. Machine vibration, for instance—the vibration that shortens the life of the machine unless checked. That's why cork-cushioning is so important.

With Armstrong's Cork Machinery Isolation, vibration and noise can be subdued in practically any moving machine. The weight, speed, and action of the machinery make no difference. Armstrong's Cork Machinery Isolation is made in three densities and seven thicknesses so the engineer can order the precise quality for the muffling of his machine.

Armstrong's Cork Machinery Isolation also protects nearby machinery. It strengthens the building structure against jarring. Promotes the efficiency and comfort of workers. Of special importance to hotels, apartment houses, and office buildings, it eliminates or greatly reduces the transmission of hum and vibration, preventing complaints from tenants.

Many special uses for Armstrong's Cork Machinery Isolation have introduced themselves. Its proved value in deadening jar and vibration has become valuable in the cork-cushioning of building structures, too.

Have you problems of noise and vibration? In factory, office building, hotel, hospital, or any other building? Then Armstrong engineers will gladly consult with you. Samples and data will also be sent on request. There is no obligation, of course. Armstrong Cork & Insulation Co., 943 Concord St., Lancaster, Pennsylvania.

Armstrong's (A) Product

Muffle These Machines

Armstrong's Cork Machinery Isolation is used for: air compressors, blowers, drill presses, drop hammers, elevator hoists, engines, fans, forging machines, machine tools, motors, motor generators, printing presses, pumps, punching machines, refrigerating machines, vacuum cleaners, and similar apparatus.

Armstrong's Cork Machinery Isolation

CALENDAR OF MEETINGS AND EXPOSITIONS

Sept. 22-26—National Metal Exposition. The twelfth annual congress and exposition sponsored by five national technical societies will be held at Stevens hotel, Chicago. Technical sessions, the annual meeting of the American Society for Steel Treating, and other features of the congress all will be held in the hotel. The 1930 show will cover approximately 75,000 square feet of floor space. Heavy displays and machinery will occupy the exhibition hall and foyer on the first floor and the second floor exhibits will be located in the grand ball room and its foyer, and in the lounge, writing room, and main dining room of the hotel. W. H. Eisenman, secretary of the American Society for Steel Treating, is director of the exposition.

Sept. 22-26—American Welding Society. Annual fall meeting to be held at Congress hotel, Chicago. W. M. Spraragen, 29 West Thirty-ninth street, New York, is technical secretary of the society.

Sept. 22-26—American Society for Steel Treating. Annual meeting to be held in connection with the National Metal exposition at Stevens hotel, Chicago. W. H. Eisenman, 7016 Euclid avenue, Cleveland, is secretary of the society.

Sept. 22-26—American Institute of Mining and Metallurgical Engineers. Annual fall meeting of the institute of metals division at Stevens hotel, Chicago. W. M. Corse, 29 West Thirty-ninth street, New York, is secretary of the institute.

Sept. 22-26—American Society of Mechanical Engineers. Annual fall meeting of iron and steel and machine shop practice divisions to be held at Stevens hotel, Chicago. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary of the society.

Sept. 29-Oct. 1—American Gear Manufacturers association. Fall meeting to be held at Hotel Clifton, Niagara Falls, Ontario, T. W. Owen, 3608 Euclid avenue, Cleveland, is secretary of the society.

Sept. 29-Oct. 3—National Safety Council. Nineteenth annual meeting to be held at Fort Pitt and William Penn hotels, Pittsburgh. Metals section meetings will be held Tuesday and Wednesday mornings and Thursday afternoon.

Oct. 7-8—Society of Automotive Engineers. Production meeting at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary of the society.

Oct. 7-10—American Road Builders' Association. Sixth international road congress Washington auditorium, Washington. An exhibition of the best products of the American highway machinery manufacturers will be held simultaneously with the congress. Delegates from 56 countries will study the exhibits to acquaint themselves with the trends in design of equipment built in this country. Since the United States produces for domestic use and export more road building machinery and equipment than any other nation, this will be an unusual opportunity for foreign delegates to grasp. A large share of the program will be devoted to the progressive ideas and methods of American engineers. It is estimated that 400 manufacturers will exhibit their products.

Oct. 8.—Gray Iron institute. Third annual convention to be held at Hotel Cleveland, Cleveland. Arthur J. Tuscany is manager of the organization.

Oct. 8-10—National Association of Farm Equipment Manufacturers. Annual convention to be held at Congress hotel, Chicago. H. J. Sameit is secretary of the association.

Oct. 13-15—American Society of Mechanical Engineers. Meeting at French Lick Springs hotel, French Lick Springs, Ind. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

Oct. 13-15—National Machine Tool Builders' association. Twenty-ninth annual convention at Hotel Aspinwall, Lenox, Mass. E. F. DuBrul, 1415 Enquirer building, Cincinnati, is general manager.

Oct. 20-25—Ninth Southern Textile Exposition. To be held at Textile hall, Greenville, S. C. The Southern Textile association will hold its semiannual meeting at Poinsett hotel, Greenville, Oct. 23.

Oct. 20-25—National Electrical Manufacturers' association. Annual meeting to be held at the Chamberlain-Vanderbilt hotel, Old Point Comfort, Va.

Oct. 20-25—Dairy and Ice Cream Machinery and Supplies association. Annual exposition in Cleveland. Roberts Everett, 225 West Thirty-fourth street, New York, is secretary.

Oct. 22—American Society of Mechanical Engineers. National meeting of the textile division at Poinsett hotel, Greenville, S. C.

Oct. 22-24—Society of Automotive Engineers. National Transportation meeting at William Penn hotel, Pittsburgh. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

Nov. 10-14—Motor and Equipment association. Fourteenth annual show to be held at Cleveland public auditorium. A convention will be held in conjunction with the exposition.

MACHINE DESIGN
September 1930

Selection of Correct Materials Rests with Designer

By Harold F. Shepherd

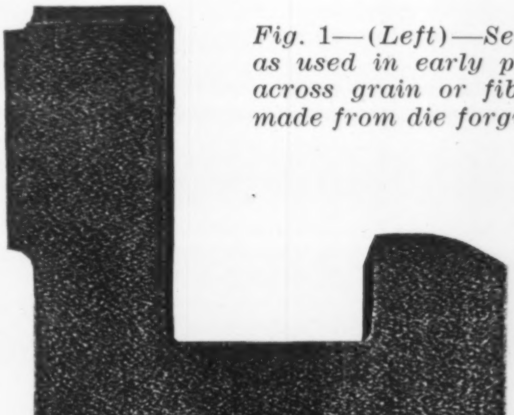
IT IS indisputable that engineers responsible for design in the numerous branches of the engineering industry can gather a considerable amount of interesting and valuable information from a study of selection of materials employed in diesel engine construction.

Developments in the engine have raised it to such high standing that now the diesel ship threatens the supremacy of steam on the seas. It also is employed largely in the oil industry for purposes of drilling, pumping and transportation. Many other present and potential uses for the engine are apparent.

All of this development and increasing application has been due to the efforts of many designers, metallurgists, founders and mechanicians who, in view of the severe tests to which materials used in diesel design are subjected, have collaborated to the end that now a comparatively perfect unit is available.

The solid injection type of diesel works at a maximum pressure of 550 to 750 pounds per square inch with starting pressures up to 1000 pounds per square inch. The heat of combustion reaches 3000 degrees Fahr. and while metal temperatures are limited by carefully directed water flow in jackets, thermal stresses due to the temperature gradient through metal walls add much to the duty of sustaining pressure loads.

Accurately repeated and timed impulses tend to sustain vibration, if opportunity is presented



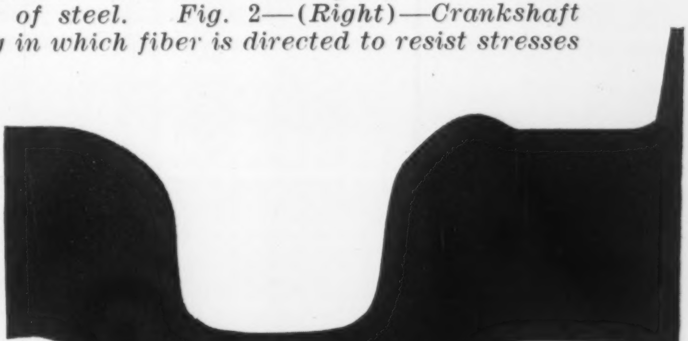
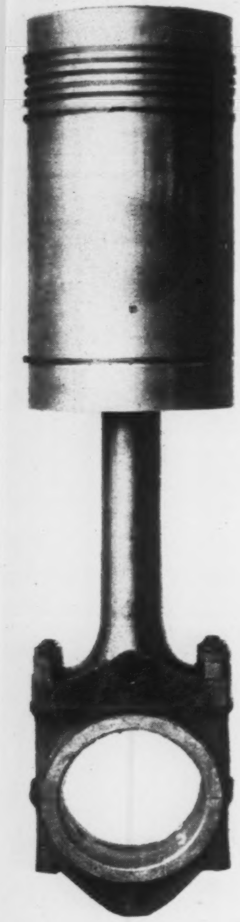


Fig. 1—(Left)—Section of diesel crankshaft blocked from billet as used in early practice. Note that bending load was taken across grain or fiber of steel. Fig. 2—(Right)—Crankshaft made from die forging in which fiber is directed to resist stresses

in less sophisticated designs, thus building stresses to values far beyond those expected from a static analysis.

Among other problems to be considered are the following: Certain functions are of such short duration that impact is severe; jacket waters tend to react in various ways with the metals exposed to them; fuel flowing at terrific velocity erodes ordinary materials; mass must be reduced by employing strong light alloys to reduce kinetic forces. These matters now are of more import than the architecture of the engine.



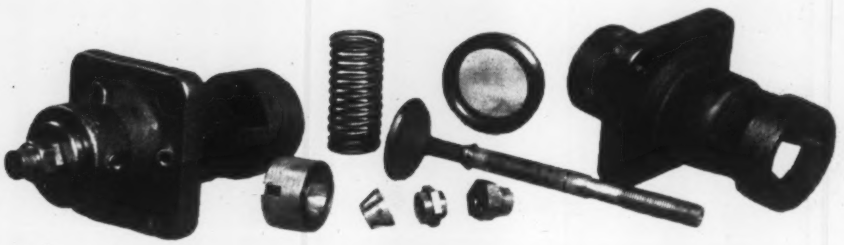


Fig. 3—(Left)—An eighteen-inch aluminum piston. Employment of light alloys is desirable for large reciprocating parts such as this to reduce kinetic forces. The connecting rod is of light tubular section, in steel. Fig. 4—(Below)—Cooled valve cages, valves and parts. Valves usually are made from high chromium, high nickel steels

In diesel work the technician owes a great debt to metallurgy for it manifestly is impossible to be master of that science and his own craft. The best the designer can hope to do is to choose good council and to observe results over the years in the great testing machine, the engine which tries out parts through many millions or even billions of motions in hours of service that extend to a decade and even a generation. Some successful material applications are detailed in this article with the wish that they may find broader application.

The much desired light weight steel casting has been produced for engine beds and frames but at such high cost that it as yet cannot be considered for ordinary commercial uses. Most engine framing, therefore, is of cast iron though not of the gray iron of old, when fracture was the only test. Steel scrap now is included in the cupola charge, from 20 to 50 per cent of the mix being steel. Involved ported castings may be made of these mixtures which produce strong dense castings of high strength. Tensile of 30,000 to 35,000 pounds square inch are common in heavy castings and recent developments produce "steel mix" castings as strong as mild steel. With ladle additions of nickel a still better casting results which takes a desirable finish for cylinders and pistons and shows good resistance to ordinary wear or even to scoring under bad conditions of fitting or use.

Aluminum alloys are employed to some extent for framing but cost generally rules them out. These alloys are discussed later.

Carbon Steel Used for Crankshafts

Our present wealth of high tensile alloy steels might seem to open up new possibilities to the crankshaft designer yet, in spite of its great burden, the crankshaft of modern multicylinder engines is the victim of incidental rather than direct forces. A large eight-cylinder single acting four-cycle engine running at 300 revolutions per minute receives 1200 impulses per minute. The turning effort curve, picturing the variable impulse applied cyclically to each of its crank pins, may be analyzed by the method of Fourier which will divide it into sine curves of a major or first harmonic, a second harmonic of no small value having a frequency of 2400 cycles per minute or 40 per second, and a number of harmonics of lesser orders. These bring about serious possibilities of torsional vibration at synchronous or critical speeds and torsional stiffness is of first importance if dynamic stresses out of all proportion to the stresses expected are to be avoided.

Unfortunately the modulus of elasticity of all steels varies little. The mildest is about as stiff within its elastic limit as the hardest and strongest and toughest. This being true and since it is necessary to design for great torsional stiffness, large diameter crankshafts with bearings as short as good design will permit are required. Torsional stiffness must be secured while bending and twisting stresses are low. Open-hearth carbon steel therefore is used for crankshafts with only such alloying as tends toward clean steel and fatigue resistance.

Still, regardless of low stresses and a shaft built like a club rather than a whip, every care is used in selecting and handling the material. Microphotographs follow the process to detect inclusions and to check the heat treatment. Equipment is required to heat treat the largest shafts, not necessarily for the highest tensile strength that the material might yield but rather for that refinement of grain which results from air or liquid quench at proper temperature and that fatigue resistance due to drawing at 1000 degrees Fahr. or more after proper refinement. Crankshaft steels usually contain .35 to .45 per cent carbon. They are made from open-hearth forging ingots which are distinguished from rolling ingots in that they are given a special anneal as they are often shipped instead of being worked at the mill from the soaking pit. The ingots are of such size that their cross-sectional area exceeds that of the crankshaft arms in ratio 2 to 1 to insure proper reduction for density of metal. Their total mass is such that all inferior metal may be cropped from top and bottom to be remelted.

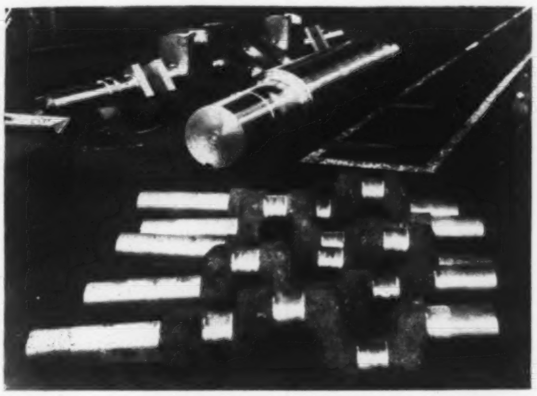


Fig. 5 — (In foreground) — Die-forged crankshafts designed for great torsional stiffness

Crankshaft Forgings Are Developed

In former practice crankshafts were blocked out of billets pressed to the section of the arms. This left the steel in the arms to resist the bending loads across the grain or fiber. Swaged or bent shafts had been used in small sizes for many years but the insistence of such engineers as H. E. Gehres of the Cooper-Bessemer Corp., and his metallurgist Peter Letz was necessary to realize large forgings of this class. Heavy presses and ingenious dies were developed by forge men and today we have large crank forgings with the fiber directed so as to resist the stress directly. Fig. 1 shows an actual halved and etched shaft of the older variety. Fig. 2 shows a die forged shaft resulting from the combined enterprise of designers and forge men.

Diesel engines make from 250,000 to one million revolutions in 24 hours. Most of the motion parts are subjected to high and varying loads making a cycle in a fraction of a second. Hardness is required to resist wear and to give a fine surface and toughness is essential to resist shock. A moderate degree of insensitiveness to small variations in heat treatment is desirable to avoid loss in manufacture and accidents in service. Nothing meets these conflicting requirements better than the case hardened part with its dual nature, a tough core and a hard exterior.

For cams and cam rollers, valve gear pins and tappets, chain sprockets, pump plungers, pump valves, etc., case hardening is essential. The ancient process of carburizing and quenching from the box is no longer practised. Triple treatment after carburizing is the only safe procedure. For S.A.E. 1015 steel:

Quench at 1650 to refine the core.

Quench at 1450 to refine case and draw core.

Quench at 450 and up to draw case.

Excess fuel oil is discharged from the common rail fuel system through a simple spring loaded relief valve. The fuel quantity is small and its pressure head 4000 pounds per square inch or more. The velocity of discharge ranges from 800 to 1000 feet per second through the orifice between valve and seat. The valve may lift at times but a few thousandths so erosion of the valve and seat is to be expected.

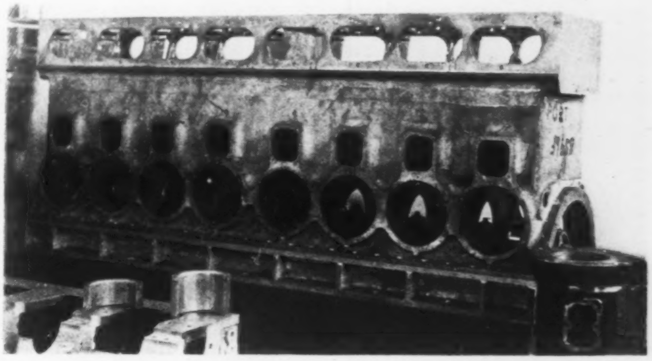


Fig. 6—A cast aluminum center frame

For this service crucible or electric steel of the high carbon chromium class containing carbon 2.20 to 2.40 and chromium 14 to 15 per cent is excellent. It fails to harden to such a degree as carbon steel but in spite of this lasts many times longer.

The fuel pump cam, in some designs, and the spray valve cam complete their function in .005 to .01 second. They do not operate with a fixed small clearance but for governing lost motion is introduced, regulating the clearance for the purpose of altering the duration and height of lift of the valve or plunger. Under these conditions the cam strikes the roller at its steeper angles and the roller is accelerated suddenly from rest with some slippage. Thus impact and abrasion are produced. The same high carbon high chromium steel that serves so well to resist erosion is outstanding for this service. To conserve steel and reduce hardening losses the cam nose usually is inserted in a mild steel or case hardened cam ring.

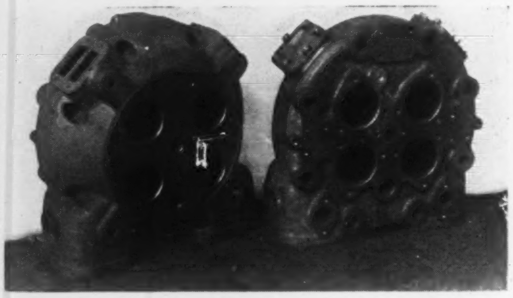


Fig. 7—Large dual valve cylinder heads

While the maximum temperature of the diesel cycle is high, reaching 3000 degrees Fahr. or more, the metal parts in the combustion space are spared by external jacketing and by the low rate of conduction between the gases and the metal walls as compared to that between the walls and the water flowing in the jackets. Even in large engines the inner wall skin temperature rarely exceeds 500 to 600 degrees Fahr. The water cooled exhaust valve poppet, however, is a mechanical nuisance to be avoided except for the largest engines. This has become possible since the advent of high chromium high nickel steels as heat resisting materials. They quite often are patented alloys containing 17 to 19 per cent chromium and 8 to 10 per cent nickel with other more or less important additions to the iron base. Finished valves or rough forgings are supplied to the engine builder by the makers. These metals have good static and dynamic properties to resist the impact and vibration of valve service.

Employment of Light Alloys

To reduce the kinetic forces produced in moving reciprocating parts through their cycles, alloys of aluminum with copper, nickel, iron (often an impurity) and magnesium are in use.

They are essential for pistons operating at high speeds. Their low modulus of elasticity and high coefficient of expansion limits the use of these alloys for connecting rods and valve push rods, or in fact any column member since tubular steel members can be made quite as light.

For reciprocating parts that are inherently stiff duralumin is invaluable. Where it suffers impact or wear, steel inserts impart necessary qualities without adding much to the weight.

Difficulties Caused by Corrosion

The exact nature of the disintegration of materials exposed to sea water and for that matter "fresh water" in the cooling system, including pumps, piping, coolers and engine jackets is still debated and so are the best analyses for the materials in contact with the sea water.

It is evident however that electrolysis is active since corrosion is most evident where the system is made up of galvanically dissimilar metals. It is often impossible to build the whole system of iron castings which because of the silicon in and on the skin are resistant when alone. Fortunately some metals are electropositive to one element and negative to others. In a galvanic system the negative element is consumed and as zinc is negative to most metals slabs of it are secured to the inner sides of clean-out plates in the jackets of heads and cylinders or placed in zinc boxes which are inserted into the piping system. The zinc disintegrates and brass, bronze, iron and steel are protected.

Since the "skin" of gray iron is far more resistant to sea water than the iron itself, where zinc is not used for protection against corrosion certain sections of the jacket water piping are rough machined inside to give the sea water direct access to the iron. As these sections are consumed by loss of the iron element they are replaced by spares carried for the purpose.

Certain alloys of brass, i. e. copper and zinc carry within themselves two of the three elements required to produce electrolytic corrosion. A great number of alloys have been proposed for sea water fittings and many of them have been named Admiralty Bronze. One stands out, quite successful in spite of its small addi-

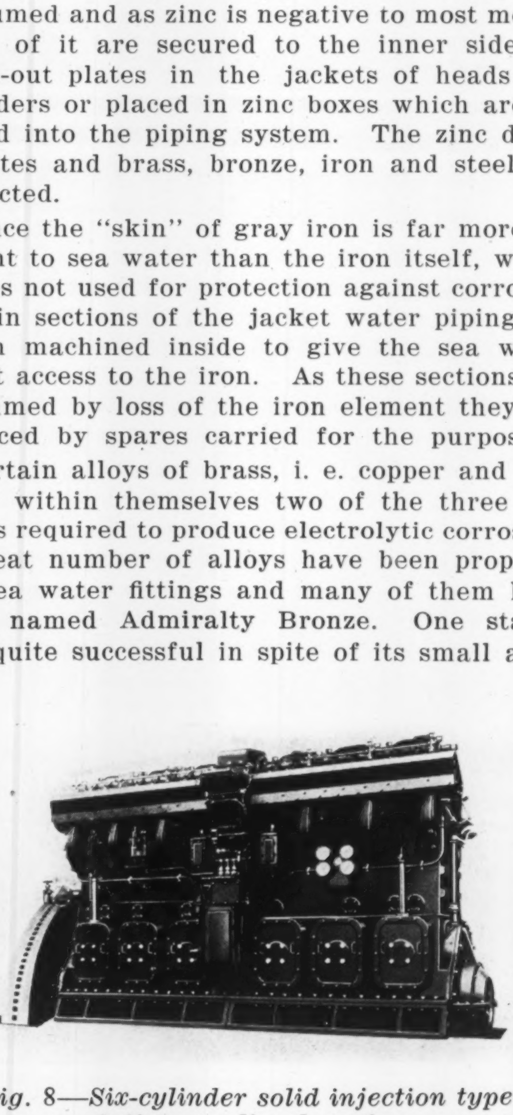


Fig. 8—Six-cylinder solid injection type stationary diesel engine

tion of zinc to give it properties desired for founding and machining. Its analysis is: copper 88, tin 10 and zinc 2 per cent.

Where tubes of rolled or drawn metal, brass or steel are required to pass through water jackets to conduct lubricating oil or to avoid long cored passages in castings they always are heavily tinned to prolong their life.

If they are required to come in contact with hot salt water as in cylinder heads even this does not always afford sufficient protection and such alloys as "18-8" are used. This is an iron alloy containing chromium 18 and nickel 8 per cent. Its service in such positions is unexcelled.

Threads are especially susceptible to corrosion, particularly when the parts are of dissimilar metals as brass pipe and iron flanges—a combination always to be avoided. For this reason stud tap holes are not drilled through into jackets, proper bosses being provided in the castings to give depth without drilling through. Brass pipe never is screwed into threaded holes in iron castings but the pipe is fitted with a brass flange which seats on a rubber gasket against the casting to which it bolts.

Salt Water Creates Difficulty

Aluminum it is well known has small resistance to alkalies. It therefore is kept away from sea water circulation in most engine designs. This precaution does not suffice however to preserve engines and fittings made of No. 12 aluminum alloy. This alloy rapidly loses its finish and more slowly its physical properties in the salt sea air. Spray and bilge water accelerate the action. The high silicon aluminum alloys show almost perfect resistance under these conditions. Physical properties of the casting alloy are as follows:

Tensile strength, lbs. per sq. in...	18,000
Proportional limit, lbs. per sq. in...	3200
Elongation, per cent	5 to 6
Brinell hardness	36 to 40

It is far harder to machine than No. 12 alloy. Tools ground as for steel generally are used and cutting speeds are about as for steel.

The compressed air devices used to control an engine all function on demand of the operator. They may be used weekly or a hundred times an hour as in the case of a ship approaching port and marine traffic. They must be ready to function even though in disuse and subject to air and moisture for a long interval before. Therefore iron casings and steel valves never are used in combination for this service. The hard phosphor bronzes work well together and show little tendency to corrode and stick.

Where forged parts are required as in poppets, stainless steel is used in bronze housings. For rams, leather or fabric cups are far superior to piston rings.

Alloys of the type metal or lead antimony class, so desirable for their low cost and antifriction properties generally have failed to withstand the shock loads of heavy reciprocating engine parts.

Tin base metals of the original Babbitt formula 88.9 tin, 7.4 antimony and 3.7 copper or slight variations from it seem to endure beyond all discovery. Slight additions of lead sometimes are used with the idea of gaining ductility. One mixture stands out for its superior hardness under high temperatures and renders excellent service in high speed engines with poorly cooled oil, as in portable engines with radiator cooling. Its composition is: copper 5.65, tin 87.45 and antimony 6.90 per cent.

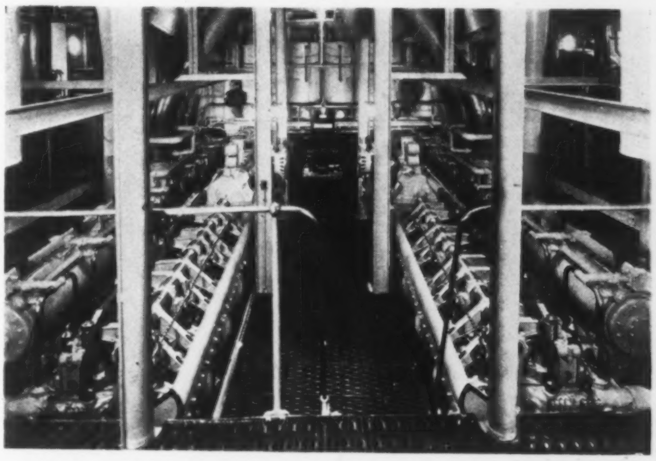


Fig. 9—Operating platform of pair of 18-cylinder marine engines rated 1500 horsepower each

When large aluminum pistons are used it is impossible to secure steel wrist pins in them as in cast iron pistons on account of the difference in expansion. Pins are either secured in the connecting rod or allowed to float in both rod and piston.

In any case it is desirable to bush the pistons but the usual wrist bronze bushing also is ruled out on account of its lesser expansion which causes it to loosen at working temperature. Accordingly aluminum alloy bushings are used (often of the piston alloy) and if lapped to a good surface wear well at unit pressures up to 2000 pounds per square inch and even more.

No attempt has been made to give exact analysis of aluminum alloys. Development in this branch of metallurgy is progressing at such a rapid rate and special heat treatment of castings and forgings is so essential that requirements are best submitted to the industry. Bed and frame castings are quite within the province of any skilled founder but the alloy is best bought from the smelter in the pig ready for casting.

With the good materials available today coupled with a generation of design experience, diesel engines rapidly are fulfilling the visions of economists who saw in this form of power the salvation of many industries.

SCANNING THE FIELD FOR IDEAS

A Monthly Digest of New Machinery, Materials, Parts and Processes, with Special Attention to Significant Design Features and Trends

A FREE-WHEEL transmission for automobiles was discussed in this department of the June issue of MACHINE DESIGN under the sub-title "Will Cars Use Free-Wheel Device?" Shortly after that issue went to press, the Studebaker Corp. began to advertise extensively its new straight eight line of cars incorporating the free-wheeling mechanism and since that time other forms of free-wheel and hydraulic transmissions have come to the front. These include an over-running clutch developed by the L. G. S. Mfg. Co., Indianapolis; also, as reported in *Automotive Industries,* a hydraulic transmission coupling adopted by the Daimler Co., and a turbine transmission introduced by the Vickers branch of the English Steel Corp. at Sheffield.

There is little doubt in view of the above developments that the old time standard clutch and gear transmission shortly will be retained only by the lower and medium priced car manufacturers, with the possibility that even these will adopt one or other form of the new devices as they gain in popularity and become established.

In action, the free-wheeling and over-running units operate in a similar manner to the coasters used on bicycles for many years. Whenever the momentum of the car on the level, or the road wheel speed on a down grade, tends to make the car travel at a higher speed than the corresponding engine speed, the car speed over-runs that of the engine with the result that the engine is disengaged instead of acting as a brake on the car. Consequently the engine is allowed to slow down to "ticking over" speed with resultant sav-

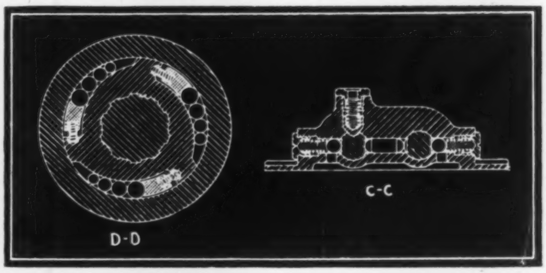


Fig. 2—(Above)—Section of free-wheel mechanism taken on line D-D. Note the three sets of rollers and the light springs for holding the rollers in the engaging position

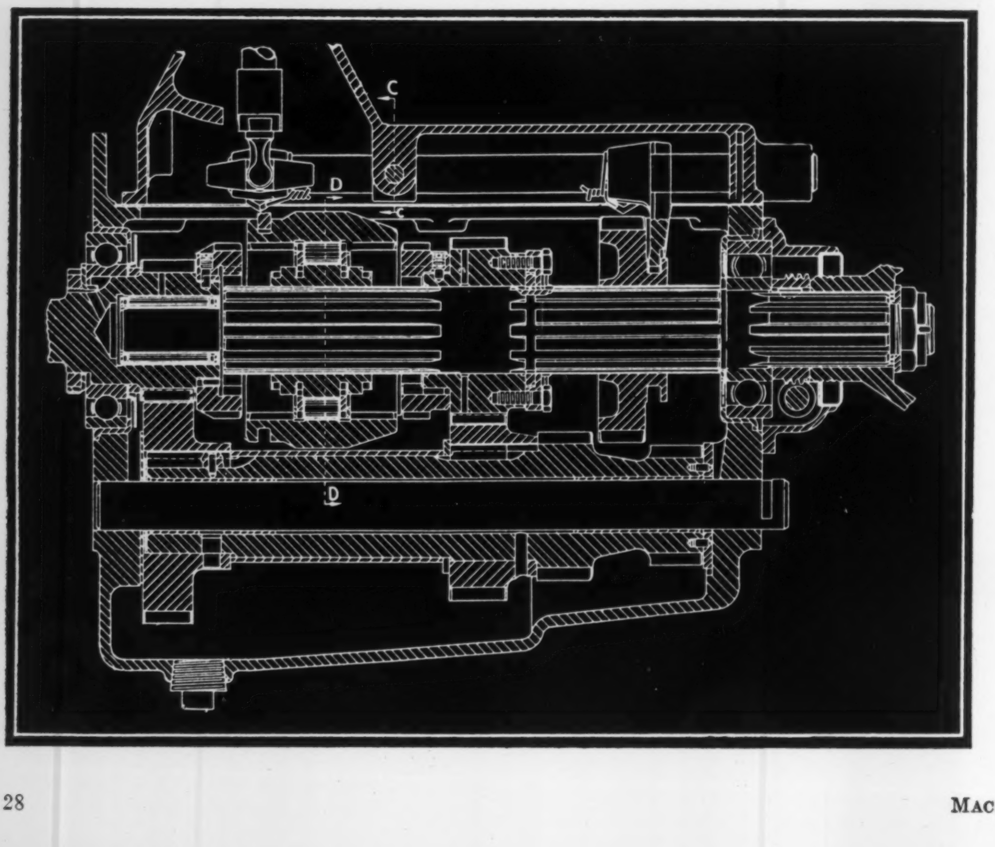


Fig. 1—(Left)—Cross-section of new transmission showing position of free-wheeling device on shaft between the intermediate and high gears

ing in gasoline consumption and wear and tear on the transmission details of the car. Silent gearshifting is provided between second and high speeds without the necessity of touching the clutch pedal.

Many interesting design features are incorporated in the various units. The device employed by the Studebaker Corp., sectional views of which are shown in Figs. 1 and 2, is operated on a somewhat similar principle to the Millam free-wheel described in the June issue, though more nearly approaching the coaster idea in its design. The unit consists of an inner cam member splined to the main driven shaft and free to be moved forward or back into high or intermediate gear position. This cam member supports an outer shell or sleeve having internal teeth at either end arranged to engage corresponding toothed clutch members on the forward pinion gear or the rearward second speed gear.

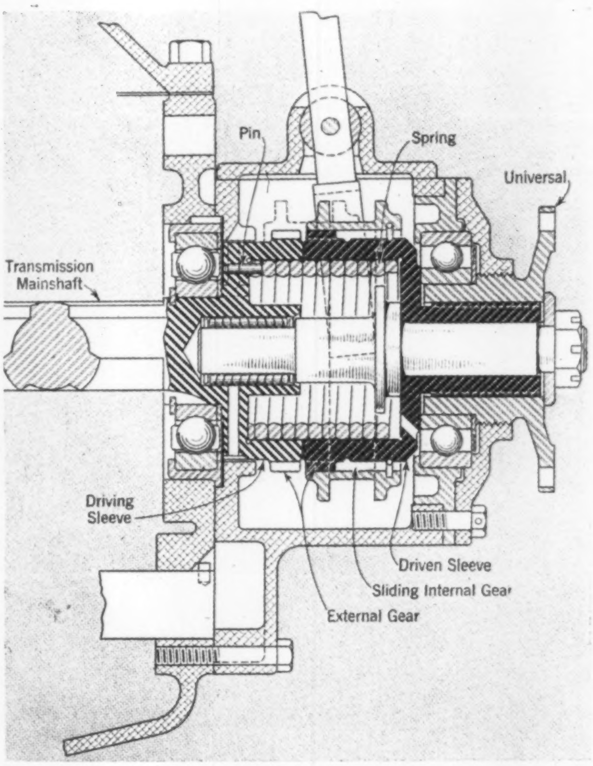


Fig. 3—Free-wheeling device of the expanding spring type. This also can be "locked out" when desired

Interposed between the inner cam member and the outer shell are twelve rollers arranged in three groups of four each which are held in contact with both members under light spring pressure. This combination of inner and outer members and rollers is, of course, arranged so that the driving torque will be transmitted from the outer member to the inner, and therefore to the drive shaft, only in the drive direction.

When it is not desirable to operate the car in the free-wheel positions, such as when descending long mountain grades, and it is required to use the engine as a brake the free-wheel unit can be rendered inoperative by means of special clutch jaws on the forward and rearward end of the inner cam member. This positive drive is obtained by depressing a button-type latch located in the top of the shift lever ball which allows moving the lever slightly farther into the intermediate or high positions to employ the positive drive gears in the conventional way.

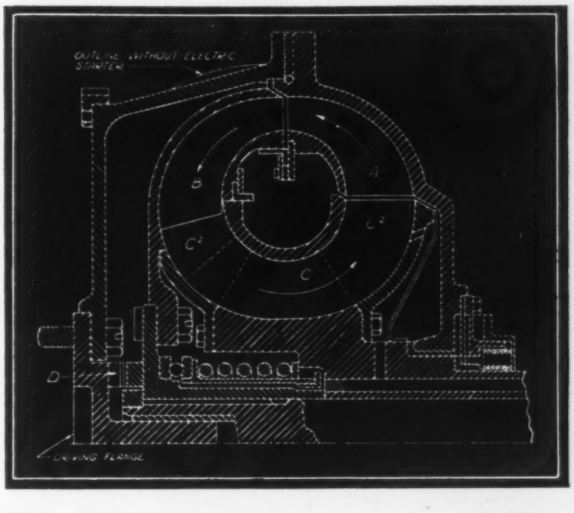


Fig. 4—Vickers-Coates hydraulic torque convertor

Drives by Spring Expansion

ANOTHER arrangement of over-running clutch or free-wheel, similar in principle but entirely different in design, has been developed by the L. G. S. Mfg. Co., Indianapolis.

Instead of employing rollers or balls and a cam this unit, as shown in Fig. 3, consists of two sleeves within which is placed a closely-coiled spring with its outer face ground to fit the sleeves with about .001-inch clearance. The springs lock the sleeves together by the "self-wrapping" principle except that the "wrapping" in this case is an expansion outward. Study of the drawing will show that with slight friction between the outer diameters of the end coils of the spring and the sleeves, caused by pressure of stop pins against the ends of the spring, an outward pressure is built up in the spring which reaches a maximum toward the center and locks the sleeves together to transmit the driving torque. On the other hand if the pressure is released from the ends of the springs, as in the case of the car speed over-running the corresponding engine speed, the spring immediately contracts to its original size and runs free in the normally driven sleeve.

The locking action of the spring is rapid, therefore there is no noticeable lag when the spring binds against the sleeves in the driving position. The spring runs in oil, the pressure

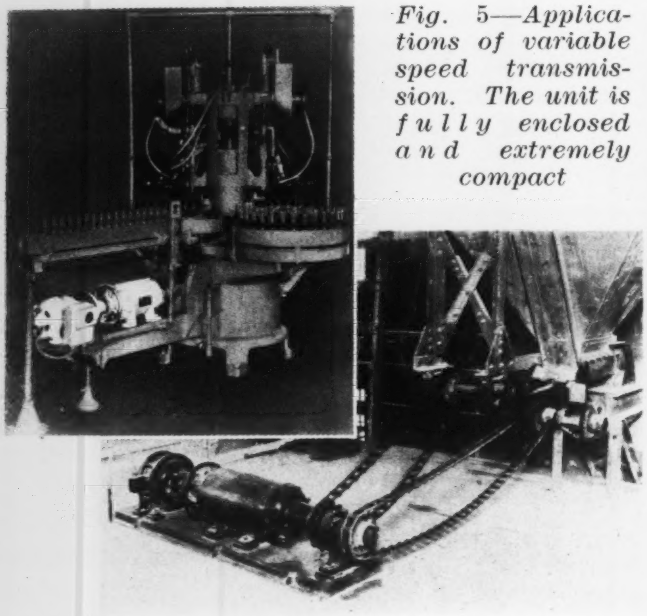


Fig. 5—Applications of variable speed transmission. The unit is fully enclosed and extremely compact

it exerts being so high that the lubricant does not interfere with the positiveness of its action.

Apart from its application to automobile transmissions there are many other uses for this type of clutch. Wherever a ratchet mechanism is necessary, for instance, the expanding spring arrangement is worthy of consideration.

Hydraulic Transmissions Introduced

THE hydraulic coupling referred to as having been adopted by the Daimler Co., displaces the usual clutch mechanism and forms a unit with the engine flywheel. A single plate clutch is provided also, but it is a much smaller unit than usual and is used for stopping and starting rather than for changing gear.

With this arrangement a car can be started on high gear by depressing the accelerator pedal and releasing the brakes. Under normal conditions, with the engine running at idling speed, the car may be left in high gear with the brakes off and yet it will not move.

The flywheel forms an oil chamber within which are two parts moving independently and constituting the driving and driven members, the former being attached to the casing. The driven member is flange-fixed to a shaft running back to the small cone clutch and a four-speed gearset. The two internal members resemble annular troughs, cup-like in section and face to face, and are divided into a large number of cells by radial webs. A small gap separates the two members, so that the driving one may rotate freely in relation to the other.

Assuming the car to be stationary and the engine running, rotation of the driving member by the engine causes the oil in its cells or cups to flow toward their outside periphery. From there, as the driven member still is stationary, the oil flows past the outside periphery of its cups, through them, and past their inside periphery to the inside periphery of the driving member cups, and from there back again to their outside periphery. In other words, the oil starts on a circulatory motion between the cups of driving and driven members. In passing from the webs of the driving to those of the driven member the oil sets the latter in motion when the engine speed is high enough. Since, even when the driven member has attained full speed, the load on it causes it to lag behind the driving member, the centrifugal forces in the latter are always larger than those in the driven member. Therefore the circulatory motion of the oil and the resultant transmission of power from the one to the other is kept up continuously.

In the Vickers turbine, shown in Fig. 4, transmission the usual flywheel and clutch are replaced by a unit consisting of primary, secondary and stationary elements. The primary element, attached to the crankshaft, forms the rotating casing which encloses the whole of the mechanism and contains also the centrifugal pump which delivers fluid to the turbine. The latter is the secondary or driven element and is attached to a flange at the front end of the transmission shaft. Fluid returns from the turbine to the pump through the third element.

In operation, as the engine speed is increased the torque is increased, since the delivery of the fluid to the secondary (driven) element increases. Actually, the input horsepower increases as the cube of the speed, the output torque increasing as the square, while the output

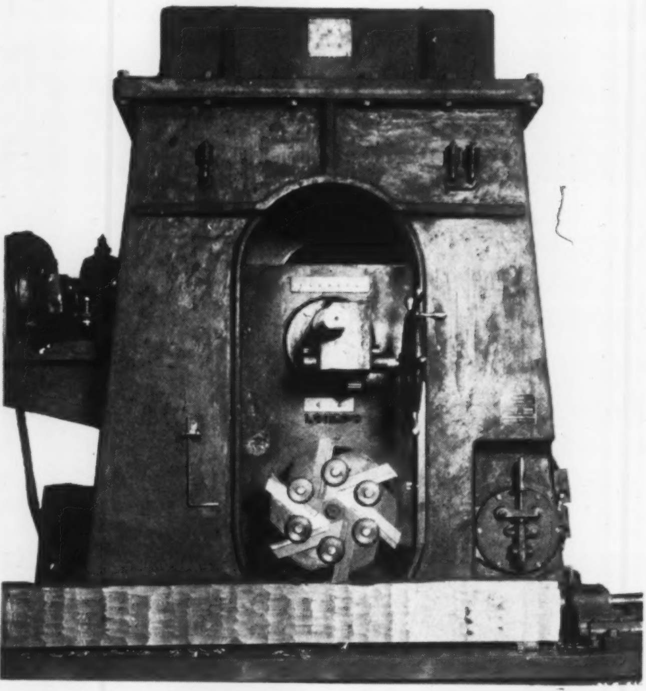


Fig. 6—Six motions of cutting head on this billet chipper are controlled by one lever

torque can be as high as three and one-half to four times the input torque. This gives a continuously variable "gearing."

Compactness Feature of Transmission

ADVANTAGE of compactness in design is characterized by a variable speed transmission developed by the Stephens-Adamson Mfg. Co., Aurora, Ill. Fig. 5 shows application of the unit, the drive to the bottling machine at the left being particularly noteworthy.

An interesting feature in the design of these transmissions is the principle involved in obtaining the speed reductions, this being somewhat similar in action to that of a roller bearing running in oil. Two ground steel inner races are driven by the high speed shaft, while the two specially shaped outer races remain stationary. Three double conical rollers travel around between the inner and outer races and cause the variable speed shaft to rotate at a slower speed, the rollers being mounted on a cage attached to the driven shaft.

By turning the handwheel the relative positions of the inner and outer races are changed, shifting the three rollers to travel in a larger or smaller circle. This causes the rollers, due to change in peripheral speed, to travel slower or faster circumferentially. The changes can, of course, be made while the unit is running.

Develops Novel Billet Chipper

EMPHASIZING the importance of ease of operation is the billet chipper shown in Fig. 6, the six motions of the cutting head of which all are made possible by the manipulation of a single lever. Control of all motor driven motions, machine carriage forward and reverse, cutter travel up and down and cutter rotation is centralized in this handle, so located that the operator has a clear view of the work. The only manual operation is the lateral movement of the cutter head by means of the pilot wheel which may be seen in the illustration.

It is interesting also to note that in this machine, developed by the Bonnot Co., Canton, O. and equipped with Timken Bearings, there is no necessity for reversal of the carriage travel after every short cut. This results in considerable saving in time, particularly in removing diagonal or transverse flaws in the billet. In removing longitudinal flaws, the carriage is moved with the cutter stationary, thus giving a simple planer action.

Another feature is the series of conveying rolls which draws the billet into an automatic chuck after which it is manipulated from side to side by an air lever. Billets can be turned through 45 or 90 degrees as desired. When a billet is completed the rolls carry it on through the machine, thereby eliminating any lost motion between finished and unfinished billets.

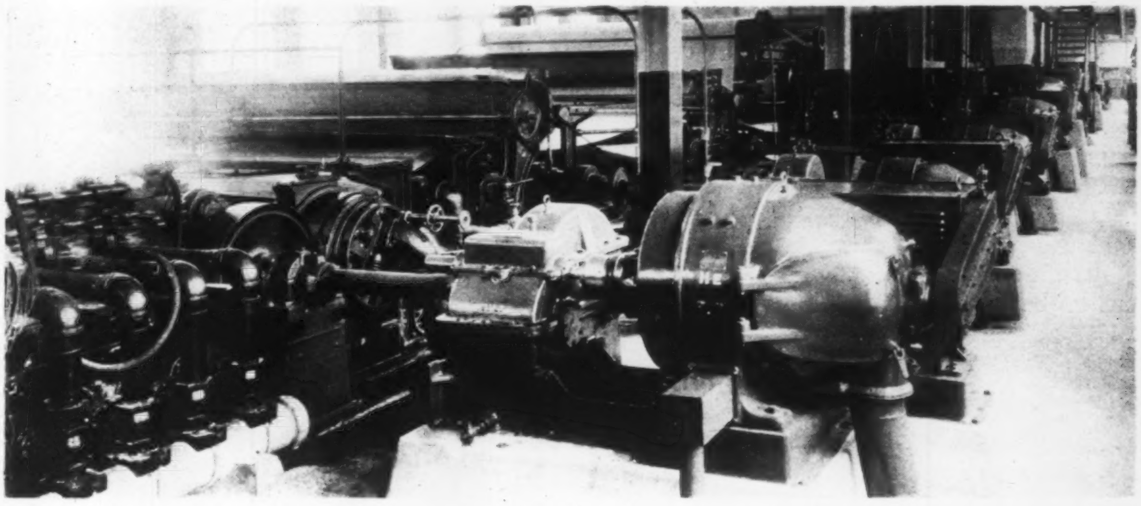


Fig. 7—Paper machine with each of its ten sections driven by an electric motor. Production cost is less than by mechanical drive

Individual Motors Prove Economical

WHILE it may seem uneconomical at first glance to employ individual motors to drive the various sections of a machine, many instances might be referred to where considerable savings in production cost have been effected by this proceedure.

An example is shown in Fig. 7 which illustrates a paper machine having ten General Electric direct current motors for driving the different shafts. It is claimed that the old mechanical drive through "back line" cone pulleys and quarter turns cost 65 cents per ton of paper for maintenance and oil whereas the motor drive at a much higher rate of production costs only 12 cents per ton.

Correcting an Error in Application of Flexure Formula

By Fred B. Seely

Professor of Theoretical and Applied Mechanics, University of Illinois

IT commonly is assumed that a channel beam with a load acting through the center of gravity of the cross-section, as indicated by the dotted lines in Fig. 1, will bend without twisting, and will develop a bending (longitudinal) stress in accordance with the simple flexure formula $S = M/Z$ in which S is the fiber unit-stress at the section for which the bending moment is M, and Z is the section modulus, the axis of symmetry of the section being the neutral axis.

However, a channel beam so loaded twists appreciably as indicated by the heavy lines in Fig. 1, and the maximum longitudinal stress at the fixed section is much greater than that given by the flexure formula.

In order to cause a channel beam to bend without twisting and to develop a bending resistance in proportion to its section modulus in accordance with the simple flexure formula, the vertical loads must lie in a plane parallel to the web but at a considerable distance back from the web as shown in Fig. 2. The intersection of this plane of loads with the axis of symmetry of a transverse cross section of the channel is called the "shear center" for the section.

The distance, e, from the center of the web to the shear center for a channel section whose web and flanges are approximately narrow rectangles may be shown by a simple approximate derivation to be given by the expression:

$$e = \frac{\frac{1}{2}\, b_1}{1 + \frac{1}{6}\,\frac{wh}{b_1 t}} = \frac{\frac{1}{2}\, b_1}{1 + \frac{1}{6}\,\frac{a_w}{a_f}} \quad \text{..........(1)}$$

in which the symbols have the meanings shown in Fig. 3.

As indicated in Fig. 4 the difference, $T_2 - T_1$, in the total tensile stress in a flange at two sections causes the longitudinal horizontal shear Q on the cross-hatched area, and for equilibrium there also must be a transverse horizontal shear H in the cross-section of each flange. The moment Hh of these shears must be balanced by the moment Ve if the channel does not twist, where V is the algebraic sum of all the external forces that lie to one side of the section (V is equal to the load P in Fig. 4). By expressing H in terms of the change in bending moment and hence in terms of V, the expression in equation (1) is found. It will be noted that the distance e depends to a considerable extent on the ratio of the area of the web a_w to the area of one outstanding flange a_f.

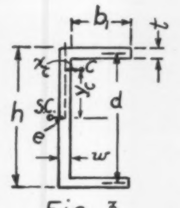


Fig. 3

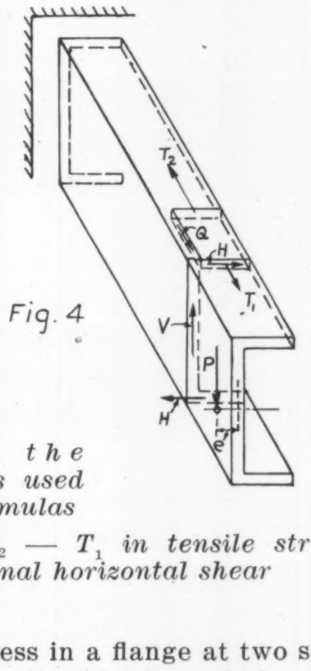


Fig. 4

Fig. 3—Illustrating the meanings of symbols used in accompanying formulas

Fig. 4—Difference $T_2 - T_1$ in tensile stress causes longitudinal horizontal shear

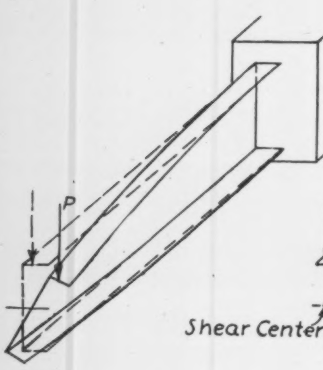


Fig. 1

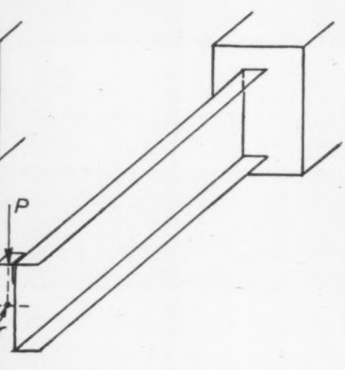


Fig. 2

Fig. 1—Showing twisting of channel section when load is applied through center of gravity.
Fig. 2—Load applied through shear center of section at distance back from web

A different derivation based on the relative rotation of two adjacent sections leads to the

INCREASED employment of steel in channel and other shaped sections has followed rapid advances made in the welding process. Therefore the accompanying article, dealing with the effect of bending loads on channel beams, is of considerable interest and value.

following expression:

$$e = \frac{d}{2} \quad \frac{x_c}{y_c} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where d is the distance between center lines of the flanges, and x_c and y_c are the co-ordinates of the center of gravity of one-half of the channel section as indicated in Fig. 3.

The shear center of the channel section is a property of the cross-section only; that is, its location depends only on the dimensions of the cross-section of the channel.

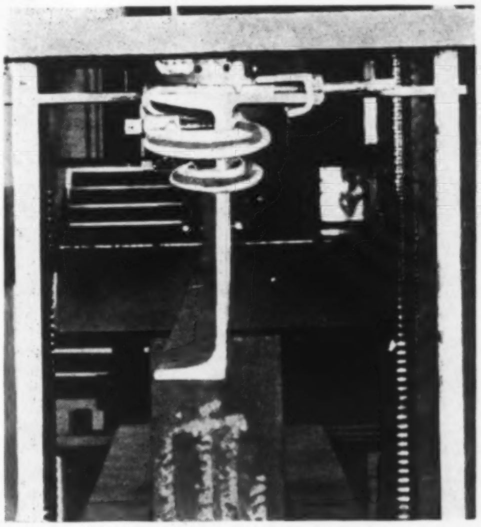


Fig. 5—Fifteen inch channel with load applied through shear center at end of cantilever

In Table I are given the values of *e* for a number of rolled steel channels, as found from tests and from the above formulas.

Fig. 5 shows a view of a 15-inch 33.9-pound cantilever channel beam with a load applied at its end through the shear center; the beam bends without twisting.

Fig. 6 shows a view of the same channel with the load applied at a point on the upper flange directly above the center of gravity of the section, that is, at a distance from the back of the channel equal to that of the center of gravity from the back; this load causes the beam to twist as it bends.

The longitudinal stress in each of a number of rolled steel channel beams when loaded through the shear center as in Fig. 5 and also when loaded through the center of gravity of the section as in Fig. 6, was found by measuring strains on a 2-inch gage line along each of the four edges of the channel at a number of sections along the length of the beam. The values of the stresses were computed from the strain measurements by using a value of 30,000,000 pounds per square inch for the modulus of elasticity.

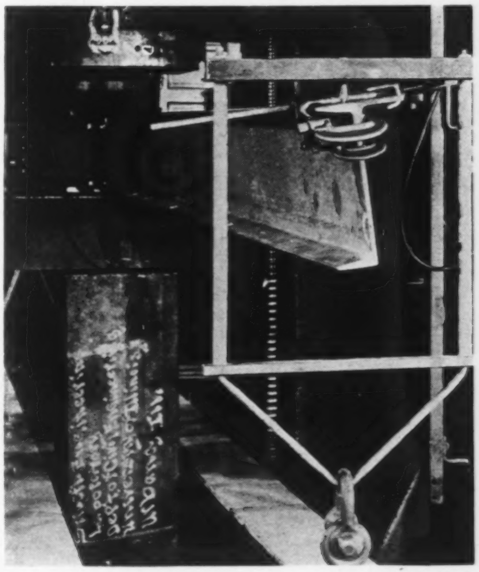


Fig. 6—Channel with load applied directly above the center of gravity of section

Fig. 7 shows the values of the stresses found in the 6-inch 8.2-pound channel when loaded through the shear center. It will be noted that the stresses are in good agreement with the simple flexure formula.

Fig. 8 shows experimental values of the longitudinal stresses in a 6-inch 15.3-pound ship channel when a vertical load of 1600 pounds is applied at the point on the flange that is directly above the center of gravity of the section, as in Fig. 6. It is clear that the twisting of the beam causes the stresses along two edges near the fixed section to be greatly in excess of those

TABLE 1

Experimental and Calculated Values of Distance of Shear Center from Web Center Line

(All dimensions in inch units; actual dimensions of sections used in calculating values of e)

Size channel	Ratio $\frac{wh}{b_1 t}$	Experimental value of e	Values of e in formula (1)	Values of e in formula (2)
4 in.- 5.4 lb.	1.68	0.50	0.56	0.47
6 in.- 8.2 lb.	2.04	0.60	0.64	0.56
6 in.-15.3 lb. (ship)	1.85	1.10	1.14	1.05
6 in.-15.5 lb. (heavy)	5.25	0.35	0.45	0.42
10 in.-15.3 lb.	2.44	0.70	0.87	0.70
15 in.-33.9 lb.	3.33	0.70	0.95	0.78

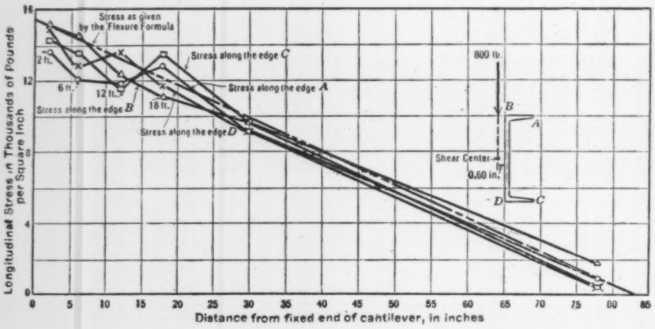


Fig. 7—Experimental values of longitudinal stress in channel with load applied through shear center at end of 84-inch cantilever

given by the simple flexure formula, and those along the other two edges to be much less than those found from the flexure formula.

It will be observed that the cantilever beam shown in Figs. 1 and 2 is equivalent to one-half of a simple beam loaded at midspan.

Little Lateral Restraint Required

The additional longitudinal stress in a channel beam arising from the fact that the transverse bending loads do not pass through the shear centers of the sections will not develop if the beam is restrained from twisting by lateral forces. And since the torsional stiffness of a channel section is relatively small, the lateral restraint required to prevent twisting is not large. It is evident, therefore, that in many uses of channels in which the transverse bending loads do not pass through the shear centers of the sections but in which some lateral restraint at a number of points along the beam is provided by other parts of the machine or structure, the twisting of the channel may be prevented and the longitudinal stress may be substantially the same as though the loads were applied through the shear centers.

It is evident also that channel sections with thick webs are especially desirable in channel beams that are free to twist as they bend since torsional stiffness of a channel section increases rapidly with the thickness of the web (approximately as the cube of the thickness of the web). In any case, however, it is important that the limitations of the flexure formula for channel beams be considered.

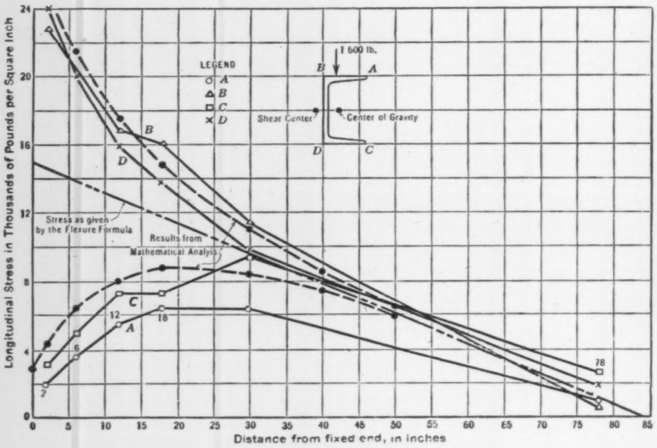


Fig. 8—Experimental values of longitudinal stress with load applied at point on flange above center of gravity

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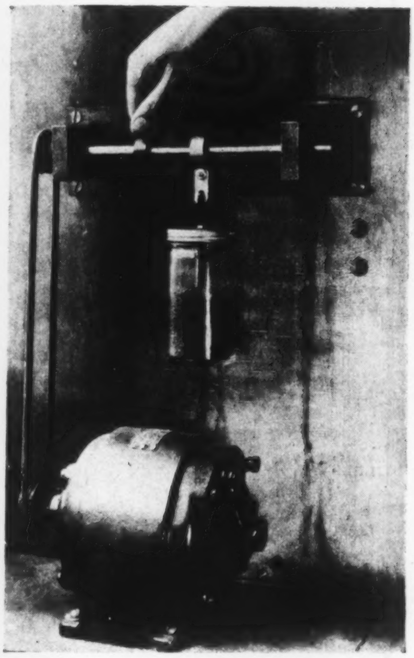
New Bearing Metal Is Developed

A NEW outstanding bearing metal in the form of a self-lubricating bearing has been developed by W. C. Wilharm of the Westinghouse research laboratories. It has been estimated that these bearings are much more efficient than the so-called "oilless" bearings in use today. Practically all bearings of the oilless type are mounted without lubricant in motors which turn only a few revolutions and then are idle for a considerable time. Automobile starting motors consume most of the output.



Laboratory test of self-lubricating bearing constructed from new metal which possesses lubricating qualities

This new bearing also can be used with lubricant. In the event the supply or film of lubricant should for any reason become inadequate, this bearing is capable of resisting the heating action of friction for a considerable length of time by means of its own lubricating qualities. After this metal has been placed on a production basis and the cost reduced, the development shows promise of revolutionizing the construction of bearings wherever they are used, whether in delicate instruments such as typewriters, calculating machines, microscopes, telescopes, etc. or in automobiles, airplanes, steamships and other types of mechanical or electrical apparatus.

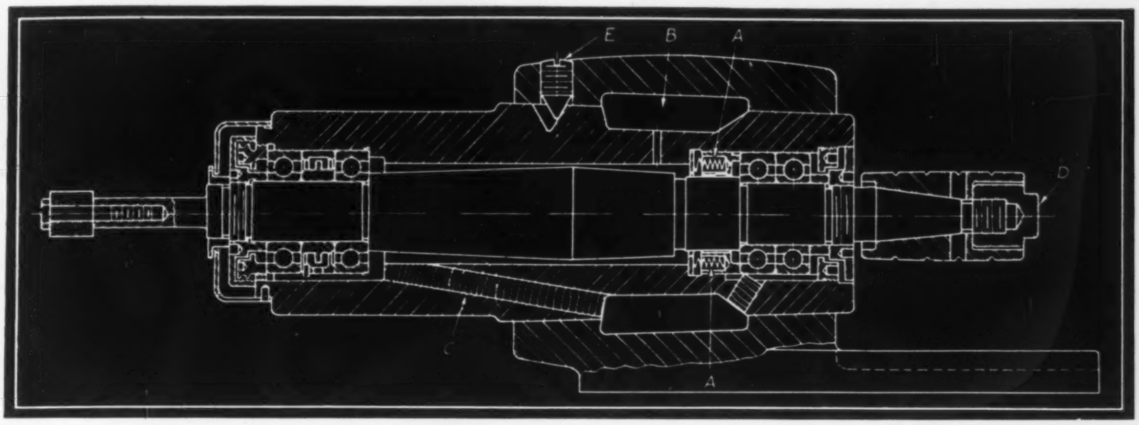


Fig. 1—Plain type spindle mounted on bearings selected for concentricity. Rear bearings have creeping fit to allow for expansion and contraction of spindle

Lubrication of High Speed Spindles Is Major Feature

By F. A. Firnhaber

IN CONJUNCTION with the article, "Designing Spindles and Mountings for Extreme Speeds" which appeared in the August issue of MACHINE DESIGN, further various types of ball bearing wheel spindles are shown in this contribution. Lubrication of the spindles, which is a highly important factor, is discussed fully. The methods referred to cover the latest and most successful developments in this field.

Fig. 1 shows a spindle as used in the Heald Machine company's internal grinder mounted on four ball bearings the specifications of which, by the maker, are "selected bearings having approximately the same eccentricity of inner and outer races, within .0001 inch if possible, and assembled with high points of all races in same plane." Bearings are adjusted by eight tension springs at *A-A*.

While the two wheel end bearings take radial and wheel thrust loads, the rear bearings are mounted with a creeping fit in the housing to allow for the expanding and contracting of the spindle, thus insuring the bearings against cramping.

At *B* is an oil reservoir, which is filled morning and noon with thin mineral oil and is connected to the bearing chambers both front and rear by 3/8-inch diameter torch wicking for sup-

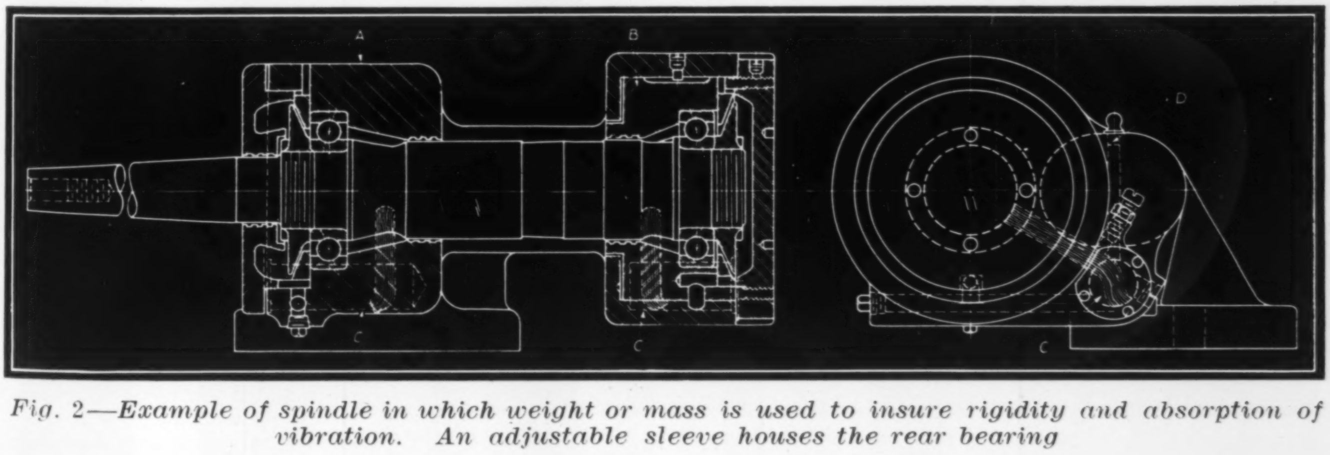


Fig. 2—Example of spindle in which weight or mass is used to insure rigidity and absorption of vibration. An adjustable sleeve houses the rear bearing

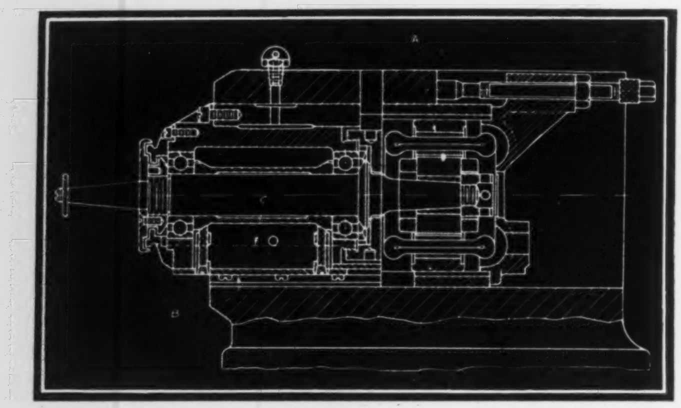


Fig. 3—Rotor of electric motor is mounted direct on end of spindle. Preloaded bearings are employed in this application

plying the bearings with the correct amount of lubrication. At *C* is a screw for use in compressing the wicking to regulate the flow of oil to the front bearings. Labyrinth sealing is used at both ends.

This spindle is for small work, carrying a wheel ¾ x ¾-inch on a ½-inch spindle nose, 2 inches long to the rear end of the wheel. The pulley is held on a tapered seat by nut *D* giving a solid mounting and making it practically a part of the spindle. It easily is removed when necessary, without disturbing any of the internal mechanism. It is V-grooved for better belt gripping power. The manufacturer recommends a light canvas belt for any speeds over 10,000 revolutions per minute. It is interesting to note that the housing outside diameter is tapered and drawn back by cone pointed screw shown at *E*.

Use of Weight in Design

Fig. 2 shows a high speed spindle for work which must be of fine finish and held to close limits. It is a good example of the use of weight or mass in the spindle housing design, insuring rigidity and absorption of vibration. Radial and axial play is eliminated by assembling the outer and inner races of both bearings by press fit, the front one into the housing frame *A*, the rear one into the heavy adjusting sleeve *B*, which may be adjusted so a sufficient thrust load is applied to bring all the balls of both bearings into positive contact with the raceways. As the spindle expands due to heat and the shaft elongates, the thrust load is relieved instead of increased as the rear bearing can float in a rearward direction.

Wick lubrication is used, but an unusual feature is added here. Rather than trust that the oil is thrown off along the tapered portions into the bearings, slingers mounted outside of each bearing cause a centrifugal pumping or sucking action, which draws the oil onto the balls and through the bearings. The oil then drains back into the reservoirs at *C-C* again, which are merely drilled holes filled with oil at *D*. Both housings have tapered bores at the rear of each bearing, thus draining oil into the bearings when the spindle is brought to a stop. This assures proper lubrication when the spindle is started again, until the oil is warmed up enough for capillary attraction to start efficiently.

Another spindle for extremely high speeds is shown in Fig. 3. It is mounted on preload bearings and driven by a motor *A*, the rotor of which is mounted on the end of the spindle, making a compact design. Preload ball bearings are so ground on the faces of the inner and outer rings, that when they are clamped in place an initial load is placed on the balls through this cramping effect. When they are assembled the surfaces of both rings will line up.

Balls May Skid in Starting

The working thrust load on a spindle is comparatively light at high speeds and the preload correspondingly small. However if the bearings are not set up under initial tension, the balls on the unloaded side of the bearings, not making positive contact with the raceways, are apt to skid under sudden starting or at extreme speeds. As a result the separators would be damaged, causing early bearing failure and destruction.

Lubrication is accomplished as stated in Fig. 2 but has a different wicking arrangement, being a much shorter spindle. Two wicks are carried by lugs in cap *B* which is the cover of the oil reservoir. Here the wicking is supported close to the spindle. The oil level is shown at *C*. In an application of this nature it was found desirable to use not more than two ball bearings making the spindle of sufficiently rigid proportions to avoid deflections. This spindle is a good example of the close spacing of the bearings.

Fig. 4 shows a two piece spindle, mounted on preloaded ball bearings, the driving end of which is shown. The two units are connected by a

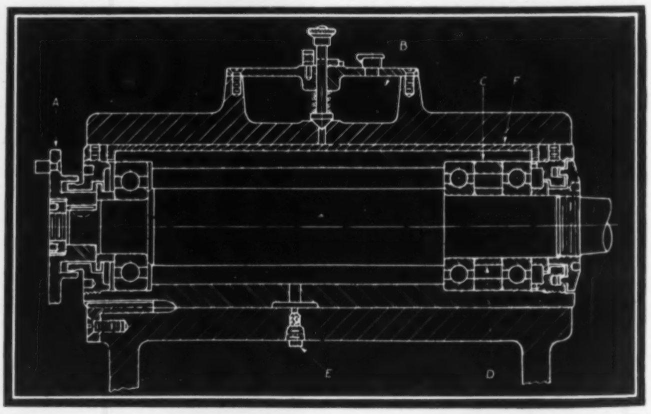


Fig. 4—Two-piece design for which flexible coupling at A is employed for connecting the units. Note lubrication reservoir above spindle

flexible coupling at *A*. The lubrication reservoir is above the spindle in this case, at *B*. As the valve is raised and turned 180 degrees it is locked in an open position and allows the oil to seep through the long piece of wick *F* to the bearings. The wheel end bearings are separated by collars of exactly the same length at *C* and *D* which control the exact preload on the bearings. The rear bearing floats. All the surplus oil is collected and drained out through the hollow plug *E* backed up by felt. This is to guard against too much oil accumulating around the bearings which would cause churning, heating and consequent bearing failure.

In Fig. 5 is a spindle made by Ex-Cell-O Aircraft & Tool Corp. and mounted on ball bearings of the double row type. The retainers are of a fabric base bakelite material which is claimed will take a high polish when properly lubricated, thus reducing bearing wear and insuring that if particles are dislodged from the retainer they are of a nonabrasive character and will not injure the bearings.

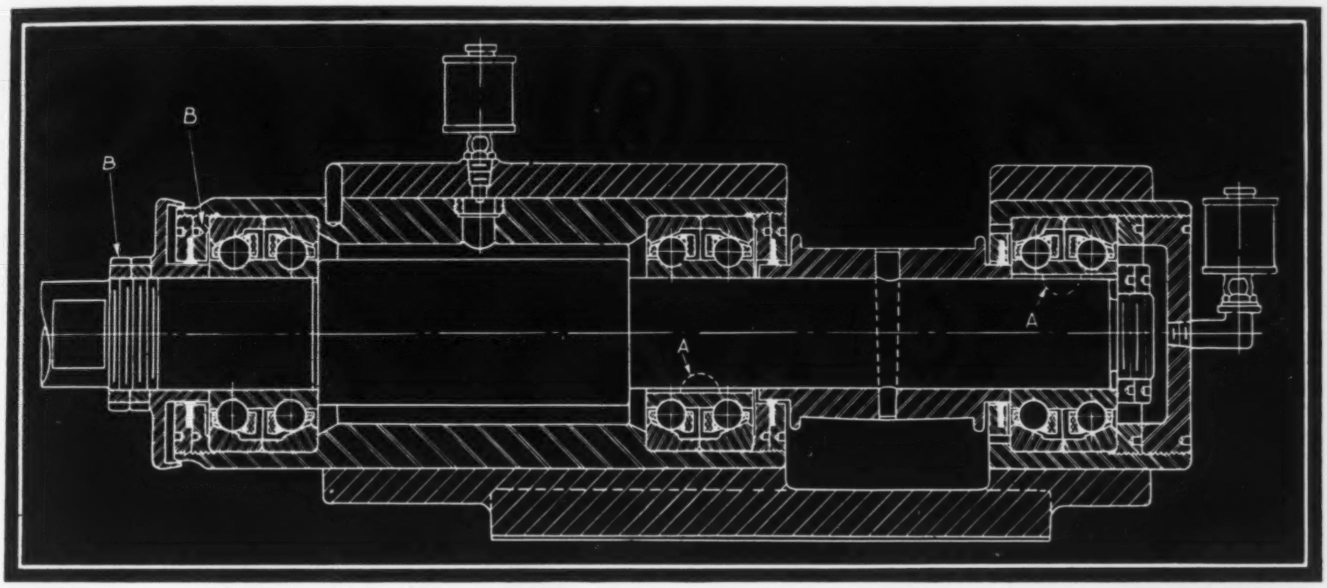


Fig. 5—Fabric base bakelite is used for bearing retainers. This offers the advantage that if particles are dislodged from retainers, the bearings remain undamaged due to the nonabrasive character of the material

Oil and Dirt Seal Is Employed

When assembling, the outer races are clamped in place metal to metal, which eliminates all end motion. They are locked by means of double lock nuts which have a felt oil and dirt seal between them. The spindle runs at 10,000 revolutions per minute.

An outboard bearing is provided for the belt pull. When the inner rings are not held against a shaft shoulder by nuts, a small Woodruff key *A-A* holds them in place. When several are used as in Fig. 5, they are placed on opposite sides of the spindle to maintain balance. It will be noticed that inner as well as outer races have the double lock nut feature *B-B* thus assuring safety from any movable part becoming loose. Sight feed oilers are used as shown.

A spindle of the removable quill type is being produced, which permits the use of interchangeable projections or quills for various diameters and lengths of holes to be ground, as frequently encountered in tool room work. Spindles of this type are not as rigid as the solid projection type. The threaded rear end of the quill, which fits loosely, is used only as a means of pulling the tapered section of the quill home in its socket.

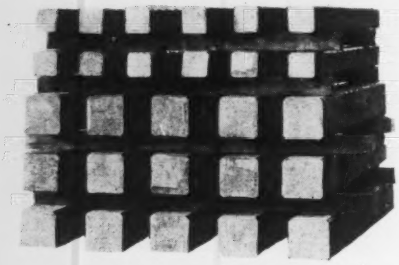
Another spindle worthy of note although not wholly a ball bearing application, is used by the Brown & Sharpe Mfg. Co. The wheel spindle proper is mounted in a split tapered bronze bushing which fits in an outer shell. This shell in turn screws into an inner shell and the whole assembly slides into the spindle base where it is secured by a series of screws. The spindle is driven by a pulley mounted on ball bearings through a slot clutch. No belt strain is taken by the spindle.

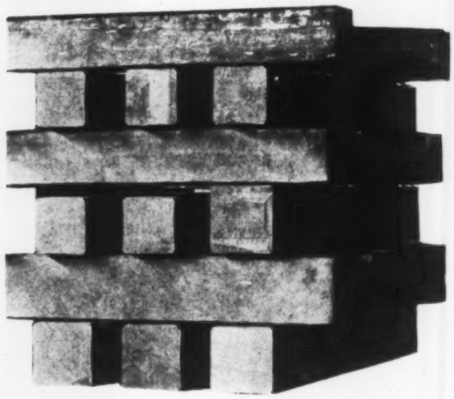
For adjustment of the spindle the sleeves are screwed together enough to take out all end motion of a flange on the spindle between the end of the bronze bushing and the inner sleeve. The spindle assembly may be removed without disturbing the adjustment or that of the pulley assembly, and another spindle inserted.

For successful work, in order to get the highest efficiency out of the machine, it is important that the proper spindle for the job be used. Increase or decrease in production depends to a large degree on the length or overhang and diameter of the spindle extension, as well as on the correct design of the mounting and the lubrication system employed.

First Section of a Three-Article Series

Steel Forgings in Design





By Lawford H. Fry

Figs. 1 and 2—Billets and die blocks forged from ingots

As a preliminary to the more detailed consideration of steel forgings it is well to consider the place for forged steel in machine parts. This is determined by the somewhat obvious fact that in selecting the material for each part of the structure the designer must be guided by the function of the part and by the cost of manufacture. From the point of view of function the designer will look towards the use of steel where a high unit stress and ability to resist shock are desired. Steel in either the cast or the forged state may meet these requirements. The cost of manufacture will, however, rule out forgings except for parts of comparatively simple design.

Except in the special case of die forgings the forging process consists in shaping a solid block of steel under a hammer or forging press. The extent to which the hot metal can be caused to flow plastically is limited and this restricts the intricacy of the shapes that can be made. Advantage of forgings over castings is due to the fact that the process of manufacture, in which the steel is poured into an open mould and then worked mechanically to shape, tends to produce a dense sound cross section. At the same time the simple design usually facilitates heat treatment to bring out the best quality of the steel. Castings on the other hand, though readily made of intricate sections, are subject to defects incidental to the method of their manufacture, such as blow holes, sand holes and shrinkage cavities. There always is some uncertainty about the complete soundness of all sections of a steel casting and owing to this the unit stress cannot be carried so high as in a steel forging even though the compositions are similar.

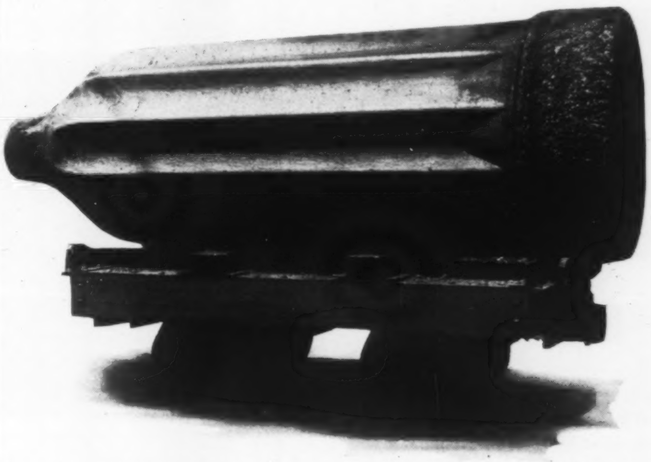
FACTORS affecting employment of steel forgings in machine design are discussed authoritatively in this series of articles prepared by Lawford H. Fry, Edgewater Steel Co., Pittsburgh, Pa., a well known figure in the metallurgical field. In this, the first of the series, Mr. Fry gives general comments and a brief outline on manufacture which contains much of value to engineers using or considering the use of forgings.

We come now to the manufacture of steel forgings. In the first place it is necessary to consider what is meant by Steel. Curiously enough there is no exact and comprehensive definition of the familiar term. It covers an extensive category of materials with widely varying properties. The varieties of steel range from the comparatively soft structural steel to the extremely hard high-speed tool steel. Essentially steel consists of a large percentage of the chemical element iron alloyed with a small percentage of carbon, and containing some manganese. This is not an exclusive definition, as it would admit cast iron which differs from steel only by having more carbon. In order to narrow the definition down to the compositions usually recognized as steel we might add that steel is or can be made malleable by heat or by heat treatment. As a further refinement it may be pointed out that the carbon does not form a direct alloy with the iron, but forms a compound, iron carbide, containing some manganese, which is or can be made malleable.

A small amount of manganese must be added during manufacture to give a sound material, and as will be seen later a number of other alloying metals may be added to give special characteristics. Nickel gives strength. Silicon is added during manufacture to eliminate gases and make the steel dense, while in larger amounts it confers desirable electrical qualities. Manganese in small quantities gives solidity and strength and if above 12 per cent gives a kind of wear resisting hardness. Vanadium facilitates heat treatment. Chromium and molybdenum give hardening properties while cobalt and tungsten are used in high-speed steels for cutting tools. The possibility of using one or more of these alloying elements to secure the special properties desired makes possible the wide range of usefulness of modern steels.

Open-Hearth Process Used for Steel

Some of the characteristics which affect the final use of steel are set up during the processes of manufacture. A brief survey of these processes therefore is in order. All important steel forgings are made of steel produced by the open-hearth process. In some cases the electric furnace is used. This is in principle an open-hearth furnace in which the electric current produces the heat instead of the flame used in the older type furnaces. The electric furnace is an excellent tool for the production of high quality steel, but it is not fool proof and cannot turn out good steel without being handled by an expert.



—*Photographs, courtesy Heppenstall Co., Pittsburgh*

Fig. 3—Forging ingot of the "big end up" type. Flutes give rapid solidification of surface metal and provide flexible contour to avoid cracking during core solidification

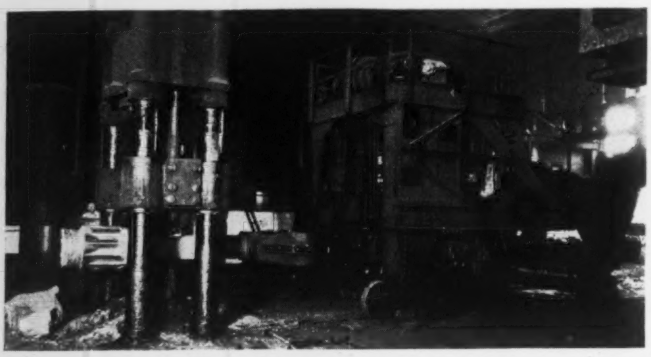
Two processes, the acid and the basic, are used in open-hearth practice. These differ in the chemical reactions involved. The open-hearth furnace consists of a shallow concave hearth on which the charge lies and over which the flame sweeps. The charge is made up of pig iron and scrap steel in varying proportions according to the type of steel to be made. After melting, the charge is held for several hours at a high temperature to allow the chemical actions which refine the steel to go forward. During the refining process the charge loses carbon, manganese and silicon. For the best steel the process will stop when the proper carbon content has been reached. Manganese and silicon are put back to remove deleterious oxides. Other alloys when desired are added in the charge or are added to the molten steel as it lies in the furnace or as it is poured into the ladle. This outline of procedure applies to both the acid and to the basic process.

The difference between the processes is chemical, depending on the composition of the refractory materials used for lining the furnace. Details are beyond the scope of the present article, but it is pertinent to note that in the basic process the slag is able to absorb some of the phosphorus which appears as an impurity in the materials of the charge. This permits low phosphorous steel to be produced from high phosphorous pig iron and thus makes available for steel production large bodies of high phosphorous iron ore which otherwise could not be used. The ores in this country having a high phosphorous content are more numerous than the low phosphorous ores, and therefore the basic process takes a leading place in tonnage production. For forgings of specially high quality the acid process has certain advantages.

It is characteristic of the acid process that in it the deoxidization of the steel during the refining period of the manufacture can be carried out more effectively than is the case in the basic process. For this reason steel of high quality is more easily made by the acid process, and this process therefore is preferred for forgings which are required to withstand transverse stresses such as is the case with ordnance or other large hollow forgings which are stressed internally.

In making steel each melt is an individual problem under the control of the melter who must regulate the reactions which take place. The final value of the steel of each melt will be dependent on the care and knowledge used by the melter. He must control the composition to have the desired percentages of carbon, manganese, silicon and of any other alloys that may be specified, and the permissible percentages of the metalloid impurities phosphorus and sulphur must not be exceeded. Further the steel must not contain an undue proportion of deleterious oxides. The degree to which this last requirement is met is not easily measured directly, and the best guarantee of satisfaction is to have the steel made by a competent and reliable manufacturer. Hurried slip-shod methods of manufacture will inevitably produce steel which will be unsatisfactory even though the chemical composition as usually determined meets all the requirements specified.

The foregoing applies to the molten steel as it is made in the furnace. From the furnace it is tapped into a ladle and is poured from the ladle into cast iron ingot molds in which it solidifies. The process of solidification is complicated and the conditions under which it proceeds have a great deal of influence on the further usefulness of the steel. In the first place it is desirable to have as much as possible of the ingot structurally solid. If the steel is poured into a mold with an open top, the steel will freeze or solidify in a shell in contact with the bottom and sides of the mold. Then the top surface exposed to radiation to the air will freeze over so that the ingot will consist of a shell of solid steel inclosing a core of still molten metal. As this core solidifies it contracts and as a consequence cavities are left along the central axis of the ingot. These cavities, known as piping, generally occur in the upper portion of the ingot and if so can be eliminated by discarding the top of the ingot.



—Photographs, courtesy American Locomotive Co., New York

Fig. 4—Fifteen hundred ton hydraulic press breaking down an ingot in process of forging. Ingot is carried by electric manipulator at right

Design Ingot Mold To Reduce Piping

With long ingots of narrow cross section secondary piping may occur at several points along the axis. Cropping off the top of the ingot to remove piping involves a waste of material if the pipe is deep. It is desirable to design the ingot mold so as to reduce piping to a minimum. To do this the cross-sectional area of the mold cavity should be larger at the top than at the bottom. It also is desirable to take steps to prevent too early a solidification of the top portion of the steel in the mold. To this end a "hot top" ingot mold is used. Designs of hot tops vary, but the principle involves the provision of a collar of heat insulating material to keep the top portion of the molten steel from being chilled by contact with the iron wall of the mold.

In a hot top ingot mold with the big end up, that is, with the cross section of the ingot increasing from bottom to top (Fig. 3), the steel freezes first in a shell in contact with the sides and bottom of the mold. Then solidification in the central or axial portion takes place, beginning at the smallest cross section at the bottom and progressing upwards. In this way the steel in the hot top is the last to solidify and remains as a reservoir to feed steel down to supply the space which would otherwise be left by the contraction of the steel as it freezes in the lower part of the ingot. The consequence is that the "pipe" or cavity in the top of the ingot is reduced to a minimum. If an ingot is cast in a poorly designed mold it may be necessary to discard thirty per cent of the ingot to get rid of the top piping, while the same steel poured into a well designed hot top mold may require only fifteen per cent discard.

Solidity of Ingot Is Affected

The conditions under which the steel solidifies in the ingot molds affects not only the mechanical solidity of the ingot, but also the chemical uniformity or homogeneity of the ingot. Steel is not a uniform chemical compound. It is made up of a number of compounds and elements which are either mixed together or are in solution with each other. When steel solidifies it does not form a structureless uniform solid like a jelly. It freezes as water does, crystals forming first at the cooler points or around nuclei floating in the metal. These crystals grow and join until the whole mass is solid. Also it must be noted that the various constituents do not all have the same freezing point. If a solution of salt in water is cooled sufficiently some of the water will freeze, and when this has taken place the unfrozen liquid will be a stronger solution of brine. If the temperature is lowered further this action will continue progressively until the final solidification takes place with ice crystals entrapping concentrated brine between them as they grow.

A similar action takes place with steel. Pure iron freezes at a higher temperature than iron having carbon or iron carbide in solution. Therefore as molten steel cools and solidifies the crystals which form first, that is at the highest temperature, will have a lower carbon content than the metal which remains molten. This action continues throughout the period of solidification and consequently the steel which

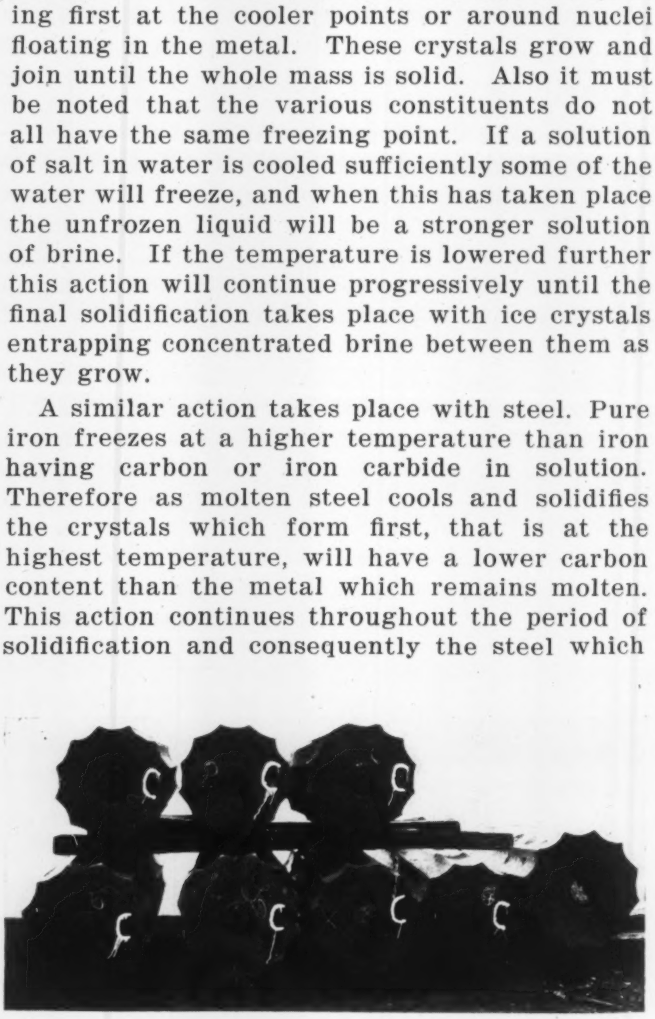


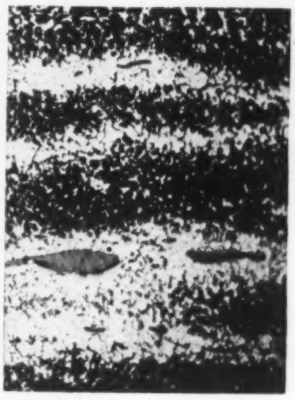
Fig. 5—Usable portions of forgings from which hot tops containing piping and injurious segregation have been removed

is last to solidify will contain a considerably higher percentage of carbon than that which froze first. This increased concentration is known as carbon segregation. In an ingot the steel that lies just below the "pipe" or shrinkage cavity in the top axial part of the ingot is the last to solidify and therefore contains the greatest carbon segregation. In a forging ingot with an average carbon content of 0.50 per cent, the portion just below the pipe may contain over one per cent of carbon.

Phosphorus and sulphur are two other constituents of steel which separate out during freezing and "segregate" in the region of final solidification. These two elements occur in forging steels as impurities only, and amounts in excess of 0.05 per cent are generally considered undesirable. For this reason, and because uniformity of carbon content is desirable to give uniformity of strength, it is necessary to discard from the top of the ingot enough metal to remove injurious segregations as well as piping.

In addition to this major segregation which leads to concentration of the carbon and of the phosphorus and sulphur at the top central portion of the ingot, a minor segregation takes place throughout the ingot during solidification. As the crystals of the purer metal grow and approach each other they may trap between them pools of molten metal containing higher carbon and more phosphorus and sulphur. This will produce local diversities of structure. Some of this is inevitable. Steel can never be perfectly uniform. It is however desirable to obtain as much uniformity as possible. To this end rapid solidification of the steel is necessary. If molten steel is allowed to cool and solidify slowly there is greater opportunity for the growth of the individual crystals and for the impurities to separate out.

Fig. 6— Normalized carbon steel axle forging showing undesirable manganese sulphide (slag) and ferrite banding



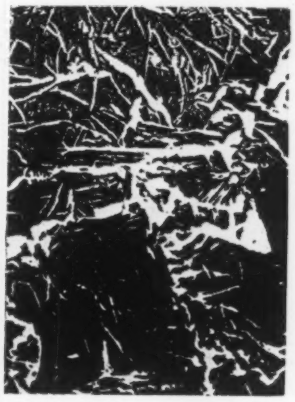


Fig. 7— Untreated carbon steel forging. Large ferrite mesh and splines show part unsuitable. Heat treatment needed

Once the minor segregation has taken place its effects will persist. The minor differences in carbon content between adjacent portions will tend to equalize out during the forging process, but differences in sulphur and phosphorus will persist and will affect the texture of the forgings. The ingot structure will be modified but not obliterated by the mechanical working by which the ingot is shaped into a forging. Consequently a forging made from a large slowly cooled ingot will not be so dense and uniform as a similar forging made from a small rapidly cooled ingot.

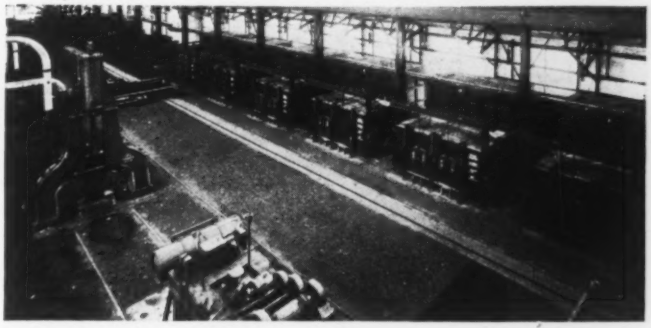


Fig. 8—View of forge shop showing regenerative furnaces in background

For special forgings where quality is important a chemical check on segregation may be made by taking drillings for analysis at the center of the section just below the discard and comparing the carbon content with that shown by analysis of drillings taken half-way between the center and the outside of the section. Usually the discard will not be made in the ingot state, but will be made as a step in the production of the forging. The check therefore will be made on the top section of a forging made direct from an ingot.

Check May Be Made from Billet

If, as is usual, the making of a billet is an intermediate step between the ingot and the forging, the carbon check may be made from the top end of the top billet from the ingot. The American Railway Association specifies that the variation in carbon content between the drillings from the center and those from the midway point shall not be greater than twelve per cent of the carbon content at the midway point.

Another check for segregation, which has also the advantage of determining whether the steel is mechanically sound as well as chemically uniform, consists in cutting a slice off the top end of the billet or forging and etching this section for half an hour or more in boiling hydrochloric acid. The structure disclosed should be solid and reasonably uniform. The structure towards the center will naturally be more open than that at the outside.

Simplifying Design Calculations by Use of Charts

By H. M. Brayton

MUCH time necessarily is spent in present-day design departments in arriving at values based on engineering formulas. Methods for reducing this work are presented from time to time in MACHINE DESIGN, Mr. Brayton's article supplementing earlier contributions on the same subject.

BECAUSE we know of no way of dividing an area into an infinite number of small areas we are obliged to derive the formula for the moment of inertia of any given area by the methods of the integral calculus. All of the engineers' handbooks have the formula for regular areas.

The designer of machines or structures is required repeatedly to calculate the moment of inertia of areas. If these areas are regular in form he generally secures a handbook, looks up the formula which applies to his problem and proceeds to substitute values therein.

The charts which accompany this article were designed to reduce this work to a minimum and their use also should reduce the chances of error. The three regular areas most commonly encountered in design work are the triangle, the rectangle and the circle. The rectangle, of course, includes the square. Fig. 1 illustrates these areas and gives the basic formula for the moment of inertia of each about different axes.

It will be noted that the formula for all moments of inertia of the rectangle and triangle is of the same form differing only in the value of the denominator. The general formula can be written:

$$I = \frac{b\,h^3}{K}$$

where b is the width of the rectangle or triangle and h the height. K is the constant depending upon where the axis is taken and I the moment of inertia the units of which will depend upon those used for b and h. If b and h are expressed in inches, as is usually the case, then I will be expressed in inches^4.

This basic formula is of the four variable product type and thus can be plotted in a way which makes it easy to solve. The chart for this is shown in Fig. 2. It is read by laying it flat and using a rule or straight edge. The cross lines in dot and dash illustrate its use. The example taken is for the triangle about its base where k has a value of 12. The height of the triangle is assumed to be 8 inches. These two values are connected by the dot-dash line as shown. The width of the base of the triangle is assumed to be 3.5 inches.

From the position of the latter point on the b scale another line is drawn through the point where the first line crossed the diagonal and extended until it meets the vertical moment of inertia scale. Here one reads the value of I to be 149 inches^4. These cross lines do not have to be actually drawn. A mark on the diagonal where the first line crosses is sufficient to show where to lay the ruler for the second line. Values of I thus can be obtained quickly—often before a handbook can be secured to look up the formula.

Special Charts Can Be Constructed

The chart shown in Fig. 2 is designed with the values shown. It may be that the reader finds his problems involve smaller or larger areas. Equations of these scales now will be given to enable the reader to construct his own chart to any size and with any values for the

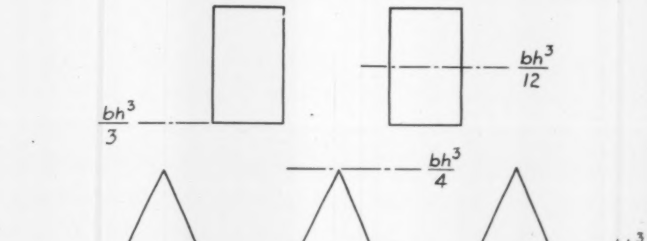


Fig. 1—Three areas commonly encountered in design work, with moment of inertia formulas

Directory of Iron, Steel and Nonf

A

A-B-C; a weldable steel containing tungsten and chromium; Darwin & Milner, Inc., Cleveland.

ADAMITE; a wear resisting alloy for rolls and heavy duty castings; Mackintosh-Hemphill Co., Pittsburgh.

ADNIC; corrosion and heat-resistant; adapted for laundry machinery, mine and paper pulp screens and condenser tubes; can be drawn, stamped and spun; copper 70, nickel 29 and tin 1 per cent; Scovill Mfg. Co., Waterbury, Conn.

ADVANCE: for rheostats, resistance spools, thermocouples, etc.; nickel, 45, copper 55 per cent; Driver-Harris Co., Harrison, N. J.

AGATHON; general brand name for alloy steels for resistance to wear, shock, stress and strain; Republic Steel Corp., Youngstown, O.

ALCOA; corrosion-resistant aluminum alloys for castings, plates, bars, wire, seamless tubing, shapes, stampings, forgings, etc.; numerous grades with varying analyses; Aluminum Company of America, Pittsburgh.

ALLEGHENY METAL; corrosion resistant; chromium 18 and nickel 8 per cent; Allegheny Steel Co., Brackenridge, Pa.

AMBRAC METAL; a corrosion-resisting alloy; nickel 20, copper 75, zinc 5 per cent; American Brass Co., Waterbury, Conn.

AMPCO METAL; an alloy resistant to corrosion; used for bushings, bearings, dies, etc.; copper 86, aluminum 10 and iron 4 per cent; American Metal Products Co., Milwaukee.

AMSCO; a high manganese steel; resistant to abrasion; for dipper teeth, draw bench chains, wheels, ball mill liners, etc.; American Manganese Steel Co., Chicago Heights, Ill.

APOLLOY METAL; resistant to corrosion; carbon .08, manganese .40, sulphur .025, phosphorus under .045 and copper .25 per cent; Apollo Steel Co., Apollo, Pa.

ASCOLOY No. 33; an alloy resistant to abrasion and corrosion; chromium 12 to 16, nickel under 0.5 per cent; Allegheny Steel Co., Brackenridge, Pa.

ASCOLOY No. 44; an alloy resistant to high temperatures and corrosion; chromium 22 to 25 and nickel 10 to 13 per cent; Allegheny Steel Co., Brackenridge, Pa.

ASCOLOY No. 55 (chromium 26 to 30, nickel under 0.6 per cent); No. 66 (chromium 16 to 19, nickel under 0.5 per cent); an alloy resistant to corrosion, Allegheny Steel Co., Brackenridge, Pa.

B

BAKER; precious metal alloys; heat and acid-resistant; Baker & Co. Inc., Newark, N. J.

BARBERITE; an alloy containing copper 88.5, nickel 5.0, tin 5, and silicon 1.5 per cent; corrosion-resisting; Barber Asphalt Co., Philadelphia.

BEARIUM METAL; for bearings etc.; low coefficient of friction and high tensile strength; contains 70 per cent copper with various percentages of tin and Bearium treated lead; Universal Bearing Metals Corp., Rochester, N. Y.

BETHALON; free machining, nonrusting, high chromium steel; Bethlehem Steel Co., Bethlehem, Pa.

BETHLEHEM; corrosion-resisting steels of chrome nickel and chrome alloy content; chrome ball race steel for cups, cones, annular and thrust ball bearings, rollers and roller paths. Permanent magnet steel No. 1, a tungsten magnet steel that is easily worked and stable, No. 2, a chromium magnet steel combining toughness and high magnetic strength; Bethlehem Steel Co., Bethlehem, Pa.

BIRDSBORO Nos. 26 and 30; No. 26 for its high physical properties and great strength; No. 30 for corrosion and fatigue-resisting; Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.

BOHNALITE; a light alloy of which aluminum is the base; for pistons

CATARACT METAL; corrosion-resisting, nickel copper alloy varying with properties desired; Niagara Falls Smelting & Refining Corp., Buffalo.

CHRISTITE No. 1; a heat-resisting alloy (tungsten 17, chromium 10 and molybdenum 2.5 per cent); Commercial Alloys Co., San Francisco, Calif.

CHROMAX; a heat-resisting alloy (nickel 35 and chromium 15 per cent); Driver-Harris Co., Harrison, N. J.

CHROME MAGNET; a 3.50 per cent chromium steel for magnets; Carpenter Steel Co., Reading, Pa.

CHROMEL No. 502; a heat-resisting alloy containing 30 to 34 nickel, 18 to 22 chromium and 38 to 48 per cent iron; Hoskins Mfg. Co., Detroit.

CIMET; a corrosion-resisting alloy in the form of bars and castings; for mine water pumps; chromium 25 and 75 per cent iron; Driver-Harris Co., Harrison, N. J.

CIRCLE "L"; Nos. 2, 3 and 4, a series of chrome molybdenum electric steel castings for high strength, and resistance to wear, heat and corrosion; No. 11, noncorrosive steel, carbon .25 to .35, and chromium 17 to 20 per cent; No. 21, heat resisting steel, carbon .30 to .40, and chromium 20 to 22 per cent; Lebanon Steel Foundry, Lebanon, Pa.

CLOVERLEAF; babbitt metal; for bushings, bearings; E. A. Williams & Son Inc., Jersey City, N. J.

CNM; a chrome-nickel alloy possessing wear-resisting qualities; George H. Smith Steel Casting Co., Milwaukee.

COBALTCROM "PRK 33"; a nondeforming, airhardened steel; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Darwin & Milner Inc., Cleveland for bar stock and forgings; Detroit Alloy Steel Co., Detroit, for castings.

COLONIAL STAINLESS STEELS, Type "A" (chromium 14), "B" (chromium 1650), "I" (chromium 14), "N" (chromium 18, nickel 8), "U" (chromium 18, nickel 8, copper 1.50 and molybdenum 1.50 per cent); for corrosion and heat-resisting purposes; Colonial Steel Co., Pittsburgh.

COLUMBIA STANDARD; a straight carbon steel; for mandrels, forming rolls, machine parts, hammers, etc.; Columbia Tool Steel Co., Chicago Heights, Ill.

COMMERCIAL; for bearings, bushings and bars; copper 83, tin 7, zinc 7 and lead 3 per cent; Buckeye Brass & Mfg. Co., Cleveland.

CORROSOIRON; an acid-resisting iron, silicon 13.50, iron 85.5 per cent; Pacific Foundry Co., San Francisco, Calif.

CROCAR; a heat-resisting alloy in the form of bars, sheets and wire; composed of chromium 12, vanadium 0.75 and cobalt 0.75 per cent; Vanadium Alloys Steel Co., Latrobe, Pa.

CRO-MOL; an alloy cast steel containing chromium and molybdenum; for hammer parts, rams, dies and sow blocks; Wheeling Mold & Foundry Co., Wheeling, W. Va.

CRUCIBLE STAINLESS IRON; No. 12 (chromium 11.5 to 13 per cent) No. 16 (chromium 15 to 18 per cent); No. 18 (chromium 18 to 23 per cent); No. 24 (chromium 24 to 30 per cent); corrosion-resistant; Crucible Steel Co. of America, New York.

CRUCIBLE STAINLESS STEELS; Grade A (chromium 12.5 to 14 per cent); Grade B (chromium 16 to 17 per cent); corrosion-resistant; Crucible Steel Co. of America, New York.

CUYO; stainless and heat-resisting steels in sizes from 1/16-inch round up to 2½-inch rounds, inclusive in all analyses; also special shapes, squares, flats, etc.; Cuyahoga Steel & Wire Co., P. O. Station D, Cleveland.

CYCLOPS No. 17; a noncorrosive steel for pump rods, still plugs, thermocouple wells, turbine blades, etc.; chromium 8, nickel 20 per cent; Cyclops Steel Co., Titusville, Pa.

CYCLOPS ORION; chrome-vanadium steel for machine parts; Cyclops Steel Co., Titusville, Pa.

CYCLOPS STAINLESS; Grade "A" (chromium 12.50, nickel 0.50 maximum); Grade "B" (chromium 17, nickel 0.50 maximum); Cyclops Steel Co., Titusville, Pa.

DELHI; special (carbon .15, silicon .75 to 1.25, and chromium 17 to 19 per cent); A (carbon .1, silicon over .5, and chromium 17 per cent); S (carbon .12, silicon .5, chromium 13.50 and nickel 2 per cent); EZ (carbon .12, silicon 1, chromium 14, and molybdenum .5 per cent); corrosion-resistant; Associated Alloy Steel Co. Inc., Cleveland.

DIAMOND G BRONZE; for bearings, bushings and mill brasses; E. A. Williams & Son Inc., Jersey City, N. J.

DOWMETAL; "M" (magnesium-manganese alloy, corrosion resistant); "T" (a complex magnesium-copper-aluminum-cadmium-manganese alloy with high thermal properties, used for pistons); Dow Chemical Co., Midland, Mich.

DUQUESNE SPECIAL; for alloy steel rolls; Special Grain for rolls and castings; Duquesne Steel Foundry Co., Pittsburgh.

DURALOY; "A" (27 to 30 chromium), "B" (16 to 18 chromium), "C" (12 to 14 chromium), "N" (21 to 24 chromium, 12 nickel), "18-8" (18 chromium, 8 nickel), "15-35" (15 chromium, 35 per cent nickel; for resisting corrosion; The Duraloy Co., Pittsburgh.

DURBAR; a high lead bronze bearing metal; Buffalo Bronze Die Cast Corp., Buffalo, N. Y.

DUREX; a bronze of the copper-tin series; porous to about 25 per cent by volume; Moraine Products Co., Dayton, O.

DURIMET; grade L in sheets, bars and rods; nickel 22.5, chromium, 19.25, silicon 3.25, molybdenum 1.10, copper 1.10 and carbon .25 per cent; cast grade has nickel 34, chromium 12.50, silicon 3.50, molybdenum 2.5, copper 1.25 and carbon .25 per cent; Duriron Co. Inc., Dayton, Ohio.

DURIRON; an acid-resisting, high silicon iron; Duriron Co. Inc., Dayton, Ohio.

DUTCH BOY BABBITT; for bearings; analysis varies for different applications; National Lead Co., New York.

E

EIS 71; an electric induction furnace alloy steel for shear knives; Heppenstall Co., Pittsburgh.

ELCOMET; a nickel-chromium steel alloy of high-silicon content; resistant to corrosion; for spinner heads, valves, pumps, etc.; La Bour Co. Inc., Elkhart, Ind.

ELECTROMET; a line of ferrous alloys of varying analyses; Electro-Metallurgical Sales Corp., New York.

ELKONITE; a hard, wear-resistant tungsten copper alloy of good electrical conductivity; for electrical contacts, motor bearings, third rail shoes, etc.; Elkon Division, P. R. Mallory & Co. Inc., Indianapolis, Ind.

ELVERITE; special castings with wear-resisting qualities; for tube mill linings, wheels, jaw crushers, sprockets, etc.; Fuller Lehigh Co., Fullerton, Pa.

ENDURIA; a special carbon spring steel; Bethlehem Steel Co., Bethlehem, Pa.

ENDURO A; resistant to heat; 18 per cent straight chromium; Babcock & Wilcox Tube Co., New York.

ENDURO AA; a heat-resisting alloy; chromium 16.5 to 18.5, silicon 0.75 and carbon 0.1 per cent maximum; Republic Steel Corp., Youngstown, O.

ENDURO KA2 (18 chromium, 8 nickel), AA (18 chromium), S and S-15 (13 per cent chromium); stainless irons resistant to heat and corrosion; Republic Steel Corp., Youngstown, O.

ERMALITE; a wear resisting alloy iron; for gears, wearing plates, friction drums and other parts subject to high stresses or wear. Erie Malleable Iron Co., Erie, Pa.

EVANSTEEL; a nickel-chrome alloy possessing wear-resisting qualities; for tractors, wheel castings, switch points, dies, ball mills, oil-pipe clamps, wheels, etc.; Chicago Steel Foundry Co., Chicago.

EVERBRITE; No. 90 (nickel 35, copper 60 per cent), for valves and chemical plants; No. 92 (nickel 35, copper 58

pins, etc.; Da
Cleveland.

FLECTO; specia
iron; does not b
vanizing or whe
temperatures; a
plication; coppe
Brass Co., Mans

FLEXO; for spr
machine parts;
Reading, Pa.

FLINTCAST; an
Pacific Foundry
Calif.

GOHI; open hear
sistant; carbon
sulphur .025,
con .003, and
per; Newport
port, Ky.

GUNITE; for ca
chinery parts
and wear resis
total carbon 2.
.75, and silicon
Corp., Rockford

HALCOMB N. C.
rosion-resistant;
racuse, N. Y.

HALCOMB REZI
made in vario
and heat-resist
Co., Syracuse,

HALCOMB STAIN
for free machinin
chrome 12 per c
to 13 per cent;
per cent; No. 18
cent; No. 24 chro
Halcomb Steel C

HALCOMB STAIN
A, chrome 12.5 p
per cent; Halcom
N. Y.

HARDTEM; a ch
num vanadium d
Heppenstall Co.,

HASTELLOY; A
num 20 per cent
molybdenum an
90, copper 3, al
and silicon plus
A, forgeable; C
alloys resistant
and corrosion;
Kokomo, Ind.

HAYSTELLITE;
bide used as a
for hard setting
and various typ
the oil and min
grades are use
dies and cutting
lite Co., Kokom

HIOLOY; Grade
sion), Grade SW
and abrasion),
to corrosion), T
ry Co., Lima a

HIPERNICK; a hi
for electrical usa
per cent each;
Chicago.

HOYT BABBITT
ings; analysis va
plication; Natio
York.

HUBBARD SPEC
steel; for wear-re
cellaneous castin
& Steel Foundry
Ind.

HYB-LUM; a corro
purpose alloy con
per cent chromiu
metals of the c
pure aluminum;
Jackson, Mich.

HYBNICKEL, "A,"
and "S"; a serie
alloys for heat
Victor Hybinette,

HYLASTIC; great
increase in weig
ganese 1.50, pho
.05; American
cago.

HY-SPEED; for bu
bars; copper 88
per cent; Buckey
Cleveland.

nferrous Alloys Used Frequently in Machine Design

Darwin & Milner, Inc.,

pecially treated malleable
not become brittle after gal-
when subjected to reduced
es; analysis depends on ap-
opper 85 plus per cent; Ohio
Mansfield, O.
springs and heat-treated
arts; Carpenter Steel Co.,
a.
an abrasion-resisting iron,
undry Co., San Francisco,

G

hearth iron; corrosion-re-
rbon .01, manganese .025,
25, phosphorus .004, sili-
nd balance iron and cop-
ort Rolling Mill Co., New-

r cams, gears, and ma-
rts where high strength
resistance are desirable;
on 2.80, combined carbon
ilicon 2 per cent; Gunite
kford, Ill.

H

. C. R. 238; heat and cor-
ant; Halcomb Steel Co., Sy-
.
REZISTAL; stainless steels
various grades; corrosion
resistant; Halcomb Steel
use, N. Y.
TAINLESS IRONS; FM2
chining, corrosion resistant,
per cent; No. 12 chrome 12
nt; No. 16 chrome 15 to 16
o. 18 chrome 18 to 20 per
chrome 24 to 26 per cent;
eel Co., Syracuse, N. Y.
TAINLESS STEELS; Grade
2.5 per cent; B, chrome 17
alcomb Steel Co., Syracuse,

a chrome nickel molybde-
um die block, heat treated;
Co., Pittsburgh.
; A (nickel 60, molybde-
cent), C (iron, chromium,
m and nickel), D (nickel
3, aluminum 1.5 per cent
plus or minus 10); grade
e; C and D, castings only
tant to high temperatures
ion; Haynes Stellite Co.,
nd.
TE; a cast tungsten car-
as a diamond substitute
tting oil well drilling tools
s types of core drills in
mining industries; other
used for wire drawing
utting tools; Haynes Stel-
okomo, Ind.
ade W (resistant to abra-
le SW (resistant to shock
on), Grade CR (resistant
n), The Ohio Steel Found-
na and Springfield, O.
a high-permeability alloy;
l usage; nickel and iron, 50
ach; Western Electric Co.,

BITT METAL; for bear-
sis varies according to ap-
National Lead Co., New

PECIAL; a nickel-chrome
ear-resisting rolls and mis-
castings; Continental Roll
oundry Co., East Chicago,

corrosion-resisting, general
y containing from 2 to 2½
romium, nickel and other
he chromium group; and
um; Sheet Aluminum Corp.,
ch.
"A," "B," "C," "D," "R"
series of nickel-chromium
heat and acid resistance;
nette, Wilmington, Del.
greater strength with no
weight; carbon .35, man-
, phosphorus .05, sulphur
can Steel Foundries, Chi-

for bushings, bearings and
er 88, tin 7 and zinc 2
Buckeye Brass & Mfg. Co.,

INLAND; copper bearing steel used largely for sheets; corrosion-resisting; copper .15 to .25 per cent; Inland Steel Co., Chicago.

IRONITE; resistant to abrasion; nickel, vanadium and chromium composition; Kinite Corp., Milwaukee.

J

JEWELL; a white fracture ductile iron, free from grain growth up to 1700 degrees Fahr.; high tensile strength; Jewell Steel & Malleable Co., Buffalo, N. Y.

JOHNSON BRONZE; used for machine parts, bushings, bearings, etc.; analyses to specifications; Johnson Bronze Co., New Castle, Pa.

K

KINITE; a high-carbon and alloy steel; resistant to abrasion and compression; for dies, anvils, cutters, mandrels, machine parts, press tools, etc.; The Kinite Corp., Milwaukee.

KLEENKUT; a high carbon high chrome nickel molybdenum steel used for shearing sheets and tin plate; Heppenstall Co., Pittsburgh.

KONEL; nickel 73, cobalt 17.5, iron 6.5, titanium 2.5 and manganese 0.2 per cent; an alloy in the form of bars, sheets and wire resistant to high temperatures; Westinghouse Research Laboratories, East Pittsburgh, Pa.

L

LUBRICO; for bearings, bushings and bars; copper 75, lead 20 and tin 5 per cent; Buckeye Brass & Mfg. Co., Cleveland.

LUCERO; corrosion resistant; copper 68, nickel 30, and iron 2 per cent; Driver-Harris Co., Harrison, N. J.

LUMEN; Alloy No. 00A copper 80, tin 20 per cent and trace of phosphorus; No. OOC, copper 84, tin 16 per cent and trace of phosphorus; No. 1, copper 88, tin 10 and zinc 2 per cent; No. 4, copper 80, tin 10, lead 10 per cent, and trace of phosphorus; No. 5, copper 85, tin 5, lead 5, zinc 5 and trace of phosphorus; No. 6, copper 78, tin 8, lead 14 and trace of phosphorus; No. 9, copper 57, tin 0.75, zinc 40, iron 1, aluminum 0.5 and manganese 0.25 per cent; No. 11C, copper 89, iron 1 and aluminum 10 per cent; No. 14, copper 90, tin 6.5, lead 1.5, and zinc 2 per cent; No. 15, copper 88.5, tin 11, lead 0.25 and phosphorus 0.25 per cent; No. 15A, copper 88, tin 10, lead 1.5, phosphorus a trace, and nickel 0.5 per cent; No. 27, copper 79.75, iron 6, aluminum 10.75 and manganese 3.5 per cent; No. 48, copper 84, tin 10, lead 2.5 and nickel 3.5 per cent; No. 54, copper 85, tin 10 and lead 5 per cent; Lumen Bearing Co., Buffalo.

LUMEN BRONZE; copper 10, zinc 86, and aluminum 4 per cent; Lumen Bearing Co., Buffalo.

LYNITE; aluminum alloy with high thermal conductivity for pistons and connecting rods; Aluminum Company of America, Pittsburgh.

M

MACKENITE METAL; heat-resistant; for retorts, annealing pots, cylinders and lead pan castings; Duncan Mackenzie's Sons Co., Trenton, N. J.

MANGANIN; high copper alloy containing manganese 10, nickel 2.5 per cent and balance copper; Driver-Harris Co., Harrison, N. J.

MANGANO; carbon 0.95, manganese 1.60, chromium 0.20; used where nonshrinking, oil quenching steel is required; Latrobe Electric Steel Co., Latrobe, Pa.

MARTIN STEEL; abrasive resistant; air hardening tool steel castings; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Detroit Alloy Steel Co., Detroit.

MAX-EL MACHINERY STEELS; used in various structural parts of all types of machinery; graded according to

to 89, chromium 10 to 14, manganese under 0.5, and carbon under 0.13 per cent; an alloy resistant to abrasion, high temperatures, and corrosion; Midvale Co., Philadelphia.

MIDVALOY; ATV I (nickel 33 to 39, chromium 10 to 12 per cent), ATV 3 (nickel 25 to 28, chromium 13 to 15 and tungsten 3 to 4 per cent), BTG (nickel 60 to 62, chromium 10 to 11, and tungsten 2 to 2.5 per cent) HR (chromium 20, nickel 7, tungsten 4 per cent), V2A (chromium 17 to 19, and nickel 8 to 9 per cent); alloys in bar form resistant to high temperatures; HR. heat and corrosion-resistant alloy developed primarily for the oil industry; Midvale Co., Philadelphia.

MILL BRASS MIX; bearings, bushings and mill brasses; E. A. Williams & Son Inc., Jersey City, N. J.

MIRACULOY; strength and ductility combined; contains chromium, nickel, manganese and molybdenum; Sivyer Steel Castings Co., Milwaukee.

MISCO; Standard (nickel 35 and chromium 15 per cent), C (nickel 9 and chromium 30 per cent), HN (nickel 65 and chromium 18 per cent); resistant to heat and corrosion; Michigan Steel Casting Co., Detroit.

MOLYBDENITE; for pinions and steel castings; Duquesne Steel Foundry Co., Pittsburgh.

MONEL METAL; a corrosion-resisting metal; manganese 2, nickel 67, iron 2, copper 28 per cent; International Nickel Co., New York.

N

NA, NA-1, NA-2, etc., alloy steel, resistant to heat, corrosion and abrasion in varying percentages of nickel and chrome; National Alloy Steel Co., Blawnox, Pa.

NATIONAL; corrosion-resistant light weight alloys; aluminum alloyed with various hardeners to meet special requirements; National Smelting Works, Cleveland.

NEWALOY; resistant to corrosion; 18-8 chromium nickel; Newton Steel Co., Youngstown, Ohio.

NICHROME IV; a heat-resisting alloy; composed of 80 nickel and 20 per cent chromium; Driver-Harris Co., Harrison, N. J.

NICHROME; nickel 60, iron 24, chromium 12, carbon 0.1 per cent; an alloy in the form of bars, sheets, tubing and wire; resistant to high temperatures; Driver-Harris Co., Harrison, N. J.

NIROSTA; a nonrusting steel; chromium 18 and nickel 8 per cent; Acme Steel Co., Chicago; American Forge Co., Chicago; Associated Alloy Steel Co. Inc., Cleveland; Babcock & Wilcox Tube Co., New York; Bacon & Mateson Forge Co., Seattle; Calorizing Co., Pittsburgh; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Nicetown, Philadelphia; Cleveland Alloy Products, Cleveland; Crucible Steel Co. of America, New York; Detroit Seamless Steel Tubes Co., Detroit; Henry Disston & Sons, Inc., Tacony, Philadelphia; Driver-Harris Co., Tacony, Philadelphia; Duriron Co., Dayton, O.; Electric Steel Foundry Co., Portland, Ore.; A. Finkl & Sons Co., Chicago; Firth Sterling Steel Co., McKeesport, Pa.; General Alloys Co., Boston; Globe Steel Tube Co., Milwaukee; Griffin Mfg. Co., Erie, Pa.; Heppenstall Co., Pittsburgh; Lukens Steel Co., Coatesville, Pa.; Michiana Products Corp., Michigan City, Ind.; Milwaukee Steel Foundry Co., Milwaukee; Monarch Foundry Co., Stockton, Calif.; Morris & Bailey Division, American Steel & Wire Co., Pittsburgh; Newton Steel Co., Youngstown, O., Ohio Seamless Tube Co., Shelby, O.; Pacific Foundry Co. Ltd., San Francisco; Pennsylvania Forge Corp., Tacony, Philadelphia; Pittsburgh Steel Co., Pittsburgh; Republic Steel Corp., Youngstown, O.; Shawinigan Stainless Steel & Alloys Ltd., Montreal, Que.; Spang-Chalfant & Co. Inc., Pittsburgh; St. Joseph Elec-

to abrasion; P. L. & M. Co., L
geles, Calif.
P.M.G. METAL; hardened cop
loy developed by Vickers-Arn
Ltd., Barrow-in-Furness, En
10 per cent tin is replaced
per cent of a special hardene
where elongation and resista
abrasion are required; marke
United States by Driver-Harr
Harrison, N. J.
PRESTO; a 1.40 per cent chr
steel for ball bearings, etc.; C
ter Steel Co., Reading, Pa.
PYRASTEEL; a chrome-nickel-
alloy possessing heat-resisting
ties; for carburizing boxes, an
pots, skid rails; Chicago Steel F
ry Co., Chicago.
PYROCAST; a nickel-chrome ir
sistant to high temperatures;
Foundry Co., San Francisco, C

Q

Q-ALLOYS; Grade K-1, nickel 66
chromium 19 to 21 per cent, f
eration up to 2200 degrees
Grade A+, obtainable in ca
forgings ,sheet, plate or bar
high resistance to oxidation; G
Alloys Co., Boston.

R

RCF; a chrome-nickel alloy pos
wear-resisting qualities; Geor
Smith Steel Casting Co., Milwa
REACTAL; heat resistant; co
nickel and chromium; Darwin
ner Inc., Cleveland.
RENYX ALUM.; resistant to
sion; nickel 4, copper 4, sili
and aluminum 91.5 per cent;
Die-Casting Corp., Long Island
N. Y.
RENYX AZN; corrosion-resistin
fine finish; copper 3, alumin
manganese .1 and zinc 92.9 per
Allied Die-Casting Corp., Long
City, N. Y.
RESILLA; a special analysis
manganese spring steel; Beth
Steel Co., Bethlehem, Pa.
RESISTAC; an acid-resisting
composed of 90 copper, 9 alum
and 1 per cent iron; American
ganese Bronze Co., Philadelphi
REZISTAL KA-2; made in v
grades; chromium nickel steel
sistant to corrosion and high
perature; Crucible Steel Co. of
ica, New York.
RITA; chrome nickel steels for
strength, superior wearing qu
and toughness; resistant to hea
corrosion; Cannon-Stein Steel
Syracuse, N. Y.
ROL-MAN MANGANESE ST
manganese 11 to 14, carbon 1
per cent; a manganese steel i
sheet and wire form; resista
abrasion; Manganese Steel Forg
Philadelphia, Pa.
RUSELITE; corrosion-resistant,
strength aluminum alloy; alum
94, copper 4 per cent and b
chromium and molybdenum;
lite Corp., Milwaukee.

S

SABECO; for use as bearings and
ings; copper, tin and lead, sp
processed; Fredericksen Co.,
naw, Mich.
SAMSON; a chrome-nickel ste
heat-treated machine parts; C
ter Steel Co., Reading, Pa.
SEYMOURITE; resistant to corr
copper 64, nickel 18 and zinc
cent; Seymour Mfg. Co., Sey
Conn.
SILCROME; heat-resisting valve
varying analyses; Ludlum Ste
Watervliet, N. Y.
SMITHCO DYNAMO; an alloy
possessing high magnetic perm
ity; George H. Smith Steel C
Co., Milwaukee.
SPECIAL DEFIRUST RUST
IRON; an alloy resistant to cor
and abrasion; chromium 16
manganese under 0.5, carbon
0.1 and nickel under 0.5; R
Iron Corporation of America,

UNIV. OF MICH.

Alloys Used Frequently in Machine Design

INLAND; copper bearing steel used largely for sheets; corrosion-resisting; copper .15 to .25 per cent; Inland Steel Co., Chicago.

IRONITE; resistant to abrasion; nickel, vanadium and chromium composition; Kinite Corp., Milwaukee.

J

JEWELL; a white fracture ductile iron, free from grain growth up to 1700 degrees Fahr.; high tensile strength; Jewell Steel & Malleable Co., Buffalo, N. Y.

JOHNSON BRONZE; used for machine parts, bushings, bearings, etc.; analyses to specifications; Johnson Bronze Co., New Castle, Pa.

K

KINITE; a high-carbon and alloy steel; resistant to abrasion and compression; for dies, anvils, cutters, mandrels, machine parts, press tools, etc.; The Kinite Corp., Milwaukee.

KLEENKUT; a high carbon high chrome nickel molybdenum steel used for shearing sheets and tin plate; Heppenstall Co., Pittsburgh.

KONEL; nickel 73, cobalt 17.5, iron 6.5, titanium 2.5 and manganese 0.2 per cent; an alloy in the form of bars, sheets and wire resistant to high temperatures; Westinghouse Research Laboratories, East Pittsburgh, Pa.

L

LUBRICO; for bearings, bushings and bars; copper 75, lead 20 and tin 5 per cent; Buckeye Brass & Mfg. Co., Cleveland.

LUCERO; corrosion resistant; copper 68, nickel 30, and iron 2 per cent; Driver-Harris Co., Harrison, N. J.

LUMEN; Alloy No. 00A copper 80, tin 20 per cent and trace of phosphorus; No. OOC, copper 84, tin 16 per cent and trace of phosphorus; No. 1, copper 88, tin 10 and zinc 2 per cent; No. 4, copper 80, tin 10, lead 10 per cent, and trace of phosphorus; No. 5, copper 85, tin 5, lead 5, zinc 5 and trace of phosphorus; No. 6, copper 78, tin 8, lead 14 and trace of phosphorus; No. 9, copper 57, tin 0.75, zinc 40, iron 1, aluminum 0.5 and manganese 0.25 per cent; No. 11C, copper 89, iron 1 and aluminum 10 per cent; No. 14, copper 90, tin 6.5, lead 1.5, and zinc 2 per cent; No. 15, copper 88.5, tin 11, lead 0.25 and phosphorus 0.25 per cent; No. 15A, copper 88, tin 10, lead 1.5, phosphorus a trace, and nickel 0.5 per cent; No. 27, copper 79.75, iron 6, aluminum 10.75 and manganese 3.5 per cent; No. 48, copper 84, tin 10, lead 2.5 and nickel 3.5 per cent; No. 54, copper 85, tin 10 and lead 5 per cent; Lumen Bearing Co., Buffalo.

LUMEN BRONZE; copper 10, zinc 86, and aluminum 4 per cent; Lumen Bearing Co., Buffalo.

LYNITE; aluminum alloy with high thermal conductivity for pistons and connecting rods; Aluminum Company of America, Pittsburgh.

M

MACKENITE METAL; heat-resistant; for retorts, annealing pots, cylinders and lead pan castings; Duncan Mackenzie's Sons Co., Trenton, N. J.

MANGANIN; high copper alloy containing manganese 10, nickel 2.5 per cent and balance copper; Driver-Harris Co., Harrison, N. J.

MANGANO; carbon 0.95, manganese 1.60, chromium 0.20; used where nonshrinking, oil quenching steel is required; Latrobe Electric Steel Co., Latrobe, Pa.

MARTIN STEEL; abrasive resistant; air hardening tool steel castings; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Detroit Alloy Steel Co., Detroit.

MAX-EL MACHINERY STEELS; used in various structural parts of all types of machinery; graded according to

to 89, chromium 10 to 14, manganese under 0.5, and carbon under 0.13 per cent; an alloy resistant to abrasion, high temperatures, and corrosion; Midvale Co., Philadelphia.

MIDVALOY; ATV I (nickel 33 to 39, chromium 10 to 12 per cent), ATV 3 (nickel 25 to 28, chromium 13 to 15 and tungsten 3 to 4 per cent), BTG (nickel 60 to 62, chromium 10 to 11, and tungsten 2 to 2.5 per cent) HR (chromium 20, nickel 7, tungsten 4 per cent), V2A (chromium 17 to 19, and nickel 8 to 9 per cent); alloys in bar form resistant to high temperatures; HR, heat and corrosion-resistant alloy developed primarily for the oil industry; Midvale Co., Philadelphia.

MILL BRASS MIX; bearings, bushings and mill brasses; E. A. Williams & Son Inc., Jersey City, N. J.

MIRACULOY; strength and ductility combined; contains chromium, nickel, manganese and molybdenum; Sivyer Steel Castings Co., Milwaukee.

MISCO; Standard (nickel 35 and chromium 15 per cent), C (nickel 9 and chromium 30 per cent), HN (nickel 65 and chromium 18 per cent); resistant to heat and corrosion; Michigan Steel Casting Co., Detroit.

MOLYBDENITE; for pinions and steel castings; Duquesne Steel Foundry Co., Pittsburgh.

MONEL METAL; a corrosion-resisting metal; manganese 2, nickel 67, iron 2, copper 28 per cent; International Nickel Co., New York.

N

NA, NA-1, NA-2, etc., alloy steel, resistant to heat, corrosion and abrasion in varying percentages of nickel and chrome; National Alloy Steel Co., Blawnox, Pa.

NATIONAL; corrosion-resistant light weight alloys; aluminum alloyed with various hardeners to meet special requirements; National Smelting Works, Cleveland.

NEWALOY; resistant to corrosion; 18-8 chromium nickel; Newton Steel Co., Youngstown, Ohio.

NICHROME IV; a heat-resisting alloy; composed of 80 nickel and 20 per cent chromium; Driver-Harris Co., Harrison, N. J.

NICHROME; nickel 60, iron 24, chromium 12, carbon 0.1 per cent; an alloy in the form of bars, sheets, tubing and wire; resistant to high temperatures; Driver-Harris Co., Harrison, N. J.

NIROSTA; a nonrusting steel; chromium 18 and nickel 8 per cent; Acme Steel Co., Chicago; American Forge Co., Chicago; Associated Alloy Steel Co. Inc., Cleveland; Babcock & Wilcox Tube Co., New York; Bacon & Mateson Forge Co., Seattle; Calorizing Co., Pittsburgh; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Nicetown, Philadelphia; Cleveland Alloy Products, Cleveland; Crucible Steel Co. of America, New York; Detroit Seamless Steel Tubes Co., Detroit; Henry Disston & Sons, Inc., Tacony, Philadelphia; Driver-Harris Co., Tacony, Philadelphia; Duriron Co., Dayton, O.; Electric Steel Foundry Co., Portland, Ore.; A. Finkl & Sons Co., Chicago; Firth Sterling Steel Co., McKeesport, Pa.; General Alloys Co., Boston; Globe Steel Tube Co., Milwaukee; Griffin Mfg. Co., Erie, Pa.; Heppenstall Co., Pittsburgh; Lukens Steel Co., Coatesville, Pa.; Michiana Products Corp., Michigan City, Ind.; Milwaukee Steel Foundry Co., Milwaukee; Monarch Foundry Co., Stockton, Calif.; Morris & Bailey Division, American Steel & Wire Co., Pittsburgh; Newton Steel Co., Youngstown, O., Ohio Seamless Tube Co., Shelby, O.; Pacific Foundry Co. Ltd., San Francisco; Pennsylvania Forge Corp., Tacony, Philadelphia; Pittsburgh Steel Co., Pittsburgh; Republic Steel Corp., Youngstown, O.; Shawinigan Stainless Steel & Alloys Ltd., Montreal, Que.; Spang-Chalfant & Co. Inc., Pittsburgh; St. Joseph Electric Steel Castings Co., St. Joseph

to abrasion; P. L. & M. Co., Los Angeles, Calif.

P.M.G. METAL; hardened copper alloy developed by Vickers-Armstrong Ltd., Barrow-in-Furness, England; 10 per cent tin is replaced by 10 per cent of a special hardener; used where elongation and resistance to abrasion are required; marketed in United States by Driver-Harris Co., Harrison, N. J.

PRESTO; a 1.40 per cent chromium steel for ball bearings, etc.; Carpenter Steel Co., Reading, Pa.

PYRASTEEL; a chrome-nickel-silicon alloy possessing heat-resisting qualities; for carburizing boxes, annealing pots, skid rails; Chicago Steel Foundry Co., Chicago.

PYROCAST; a nickel-chrome iron resistant to high temperatures; Pacific Foundry Co., San Francisco, Calif.

Q

Q-ALLOYS; Grade K-1, nickel 66 to 68, chromium 19 to 21 per cent, for operation up to 2200 degrees Fahr.; Grade A+, obtainable in castings, forgings ,sheet, plate or bar stock; high resistance to oxidation; General Alloys Co., Boston.

R

RCF; a chrome-nickel alloy possessing wear-resisting qualities; George H. Smith Steel Casting Co., Milwaukee.

REACTAL; heat resistant; contains nickel and chromium; Darwin & Milner Inc., Cleveland.

RENYX ALUM.; resistant to corrosion; nickel 4, copper 4, silicon .5 and aluminum 91.5 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RENYX AZN; corrosion-resisting and fine finish; copper 3, aluminum 4, manganese .1 and zinc 92.9 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RESILLA; a special analysis silico-manganese spring steel; Bethlehem Steel Co., Bethlehem, Pa.

RESISTAC; an acid-resisting metal composed of 90 copper, 9 aluminum, and 1 per cent iron; American Manganese Bronze Co., Philadelphia, Pa.

REZISTAL KA-2; made in various grades; chromium nickel steels, resistant to corrosion and high temperature; Crucible Steel Co. of America, New York.

RITA; chrome nickel steels for high strength, superior wearing qualities and toughness; resistant to heat and corrosion; Cannon-Stein Steel Corp., Syracuse, N. Y.

ROL-MAN MANGANESE STEEL; manganese 11 to 14, carbon 1 to 1.4 per cent; a manganese steel in bar, sheet and wire form; resistant to abrasion; Manganese Steel Forge Co., Philadelphia, Pa.

RUSELITE; corrosion-resistant, high strength aluminum alloy; aluminum 94, copper 4 per cent and balance chromium and molybdenum; Ruselite Corp., Milwaukee.

S

SABECO; for use as bearings and bushings; copper, tin and lead, specially processed; Fredericksen Co., Saginaw, Mich.

SAMSON; a chrome-nickel steel for heat-treated machine parts; Carpenter Steel Co., Reading, Pa.

SEYMOURITE; resistant to corrosion; copper 64, nickel 18 and zinc 18 per cent; Seymour Mfg. Co., Seymour, Conn.

SILCROME; heat-resisting valve steel; varying analyses; Ludlum Steel Co., Watervliet, N. Y.

SMITHCO DYNAMO; an alloy steel possessing high magnetic permeability; George H. Smith Steel Casting Co., Milwaukee.

SPECIAL DEFIRUST RUSTLESS IRON; an alloy resistant to corrosion and abrasion; chromium 16 to 18; manganese under 0.5, carbon under 0.1 and nickel under 0.5; Rustless Iron Corporation of America, Baltimore, Md.

chromium iron, heat resisting; No. 21, a nickel and chrome alloy, heat resisting; No. 22, a high-chromium-nickel iron, acid resisting; Wm. J. Sweet Foundry Co., Newark, N. J.

T

TANTIRON; a high-silicon iron alloy possessing corrosion-resisting qualities; Bethlehem Foundry & Machine Co., Bethlehem, Pa.

TEMP-ALLOY; heat-resisting steel; Duquesne Steel Foundry Co., Pittsburgh.

TEMPALOY; a hardenable copper alloy; copper 95, nickel 4 and silicon 1 per cent; American Brass Co., Waterbury, Conn.

THERMALLOY; nickel 66.5, copper 30 and iron 2 per cent; for magnetic shunts; Electro Alloys Co., Elyria, O.

TIGERLOY; alloy steel castings for high strength, resistance to shock and abrasion; Massillon Steel Casting Co., Massillon, O.

TIMANG; 12 per cent manganese steel; can be rolled, drawn, forged or shaped; for wire screens, welding rod, etc.; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TIMAXX; heat-resisting manganese steel; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TISCO; manganese steel castings; 12 per cent manganese; for severe service in wearing parts of excavating, crushing machinery, etc.; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TOBIN BRONZE; a corrosion-resisting metal; for pump shafts, propeller blades, etc.; copper 60, zinc 39.25, tin 0.75 per cent; American Brass Co., Waterbury, Conn.

TONCAN; an iron alloyed with copper and molybdenum; corrosion resistant; Republic Steel Corp., Youngstown, O., Babcock & Wilcox Tube Co., New York.

TOPHET A; a corrosive resisting alloy; nickel 80, chromium 20 per cent; Grade "C," an alloy in the form of bars, sheets and wire; nickel 60, chromium 12 per cent and iron; resistant to high temperatures and corrosion; Gilby Wire Co., Newark, N. J.

TUFALOY; an alloy cast steel possessing a high yield point and wear resisting qualities; Fort Pitt Steel Casting Co., McKeesport, Pa.

U

UNILOY; No. 1409, a noncorrosive stainless iron (chromium 12 to 14, carbon 0.1 per cent); No. 1809, a noncorrosive high-chrome stainless iron (chromium 16 to 18, carbon 0.1 per cent); No. 2825, a noncorrosive iron heat resisting to 2000 degrees Fahr. (chromium 28 per cent); Cyclops Steel Co., Titusville, Pa.

UNILOY; No. 1, noncorrosive, heat resisting to 1600 degrees Fahr. (chromium 18, nickel 8 per cent); No. 2, noncorrosive, heat resisting to 1800 degrees Fahr. (chromium 21, nickel 12 per cent); Cyclops Steel Co., Titusville, Pa.

UNIONALOY; an iron base alloy; for mill guides, tube mill plugs, hopper liners; resistant to abrasion; Union Steel Casting Co., Pittsburgh.

UNIVAN; an alloy cast steel; resistant to shock and stress; vanadium 0.16 minimum, phosphorus and sulphur 0.05 per cent maximum; for locomotive frames, wheel centers, crossheads; Union Steel Casting Co., Pittsburgh.

U. S. S. CHROMIUM; grade 18-8, a corrosion and heat-resisting steel, chromium 17 to 19, nickel 7 to 9 per cent; grade 12-14, a corrosion and abrasion-resisting alloy for forgings, chromium 12 to 14 and carbon 10 per cent maximum; grade 16-18, a corrosion and heat-resisting alloy, chromium 16 to 18 and carbon 10 per cent maximum; Illinois Steel Co., Chicago.

V

VASCO; stainless steels; corrosion and heat-resistant; Type A, chromium 14; B, chromium 16.50; I, chromium 14;

alloys for castings, plates, bars, wire, seamless tubing, shapes, stampings, forgings, etc.; numerous grades with varying analyses; Aluminum Company of America, Pittsburgh.

ALLEGHENY METAL; corrosion resistant; chromium 18 and nickel 8 per cent; Allegheny Steel Co., Brackenridge, Pa.

AMBRAC METAL; a corrosion-resisting alloy; nickel 20, copper 75, zinc 5 per cent; American Brass Co., Waterbury, Conn.

AMPCO METAL; an alloy resistant to corrosion; used for bushings, bearings, dies, etc.; copper 86, aluminum 10 and iron 4 per cent; American Metal Products Co., Milwaukee.

AMSCO; a high manganese steel; resistant to abrasion; for dipper teeth, draw bench chains, wheels, ball mill liners, etc.; American Manganese Steel Co., Chicago Heights, Ill.

APOLLOY METAL; resistant to corrosion; carbon .08, manganese .40, sulphur .025, phosphorus under .045 and copper .25 per cent; Apollo Steel Co., Apollo, Pa.

ASCOLOY No. 33; an alloy resistant to abrasion and corrosion; chromium 12 to 16, nickel under 0.5 per cent; Allegheny Steel Co., Brackenridge, Pa.

ASCOLOY No. 44; an alloy resistant to high temperatures and corrosion; chromium 22 to 25 and nickel 10 to 13 per cent; Allegheny Steel Co., Brackenridge, Pa.

ASCOLOY No. 55 (chromium 26 to 30, nickel under 0.6 per cent); No. 66 (chromium 16 to 19, nickel under 0.5 per cent); an alloy resistant to corrosion, Allegheny Steel Co., Brackenridge, Pa.

B

BAKER; precious metal alloys; heat and acid-resistant; Baker & Co. Inc., Newark, N. J.

BARBERITE; an alloy containing copper 88.5, nickel 5.0, tin 5, and silicon 1.5 per cent; corrosion-resisting; Barber Asphalt Co., Philadelphia.

BEARIUM METAL; for bearings etc.; low coefficient of friction and high tensile strength; contains 70 per cent copper with various percentages of tin and Bearium treated lead; Universal Bearing Metals Corp., Rochester, N. Y.

BETHALON; free machining, nonrusting, high chromium steel; Bethlehem Steel Co., Bethlehem, Pa.

BETHLEHEM; corrosion-resisting steels of chrome nickel and chrome alloy content; chrome ball race steel for cups, cones, annular and thrust ball bearings, rollers and roller paths. Permanent magnet steel No. 1, a tungsten magnet steel that is easily worked and stable, No. 2, a chromium magnet steel combining toughness and high magnetic strength; Bethlehem Steel Co., Bethlehem, Pa.

BIRDSBORO Nos. 26 and 30; No. 26 for its high physical properties and great strength; No. 30 for corrosion and fatigue-resisting; Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.

BOHNALITE; a light alloy of which aluminum is the base; for pistons, piston rings, etc.; Bohn Aluminum & Brass Corp., Detroit, Mich.

BUNTING; list of over 150 bronze alloys for various purposes including resistance to heat, pressure and corrosion, low friction; varying analyses; Bunting Brass & Bronze Co., Toledo, Ohio.

C

CALITE; Grade "A" (carbon 0.80, nickel 35, chromium 15 per cent) a heat-resisting alloy for carburizing boxes, retorts and hearth plates; Grade "B," (carbon 1.50, nickel 6, chromium 18 per cent), for elevated temperatures; Calorizing Co., Pittsburgh.

CARPENTER Nos. 314, 317 and 408; chrome-nickel steels with chromium from 0.75 in No. 408 to 1.50 in No. 314 and nickel from 1.75 in No. 317 to 3.50 per cent in No. 314; for heat-treated machine parts; Carpenter Steel Co., Reading, Pa.

CARPENTER No. 158 chrome-nickel steel (chromium 1.50, nickel 3.50 per cent); for case hardened machine parts; Carpenter Steel Co., Reading, Pa.

CARPENTER STAINLESS, Nos. 1, 2, 3, 4 and 5; chromium steels for resisting heat and corrosion; Carpenter Steel Co., Reading, Pa.

CASTALOY; air hardening tool steel castings; abrasive resistant; chromium 12 to 14, and carbon 1.5 to 1.6 per cent; Detroit Alloy Steel Co., Detroit.

of machinery; graded according to

castings for high strength, and tance to wear, heat and corrosion; No. 11, noncorrosive steel, carbon .25 to .35, and chromium 17 to 20 per cent; No. 21, heat resisting steel, carbon .30 to .40, and chromium 20 to 22 per cent; Lebanon Steel Foundry, Lebanon, Pa.

CLOVERLEAF; babbitt metal; for bushings, bearings; E. A. Williams & Son Inc., Jersey City, N. J.

CNM; a chrome-nickel alloy possessing wear-resisting qualities; George H. Smith Steel Casting Co., Milwaukee.

COBALTCROM "PRK 33"; a nondeforming, airhardened steel; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Darwin & Milner Inc., Cleveland for bar stock and forgings; Detroit Alloy Steel Co., Detroit, for castings.

COLONIAL STAINLESS STEELS, Type "A" (chromium 14), "B" (chromium 1650), "I" (chromium 14), "N" (chromium 18, nickel 8), "U" (chromium 18, nickel 8, copper 1.50 and molybdenum 1.50 per cent); for corrosion and heat-resisting purposes; Colonial Steel Co., Pittsburgh.

COLUMBIA STANDARD; a straight carbon steel; for mandrels, forming rolls, machine parts, hammers, etc.; Columbia Tool Steel Co., Chicago Heights, Ill.

COMMERCIAL; for bearings, bushings and bars; copper 83, tin 7, zinc 7 and lead 3 per cent; Buckeye Brass & Mfg. Co., Cleveland.

CORROSOIRON; an acid-resisting iron, silicon 13.50, iron 85.5 per cent; Pacific Foundry Co., San Francisco, Calif.

CROCAR; a heat-resisting alloy in the form of bars, sheets and wire; composed of chromium 12, vanadium 0.75 and cobalt 0.75 per cent; Vanadium Alloys Steel Co., Latrobe, Pa.

CRO-MOL; an alloy cast steel containing chromium and molybdenum; for hammer parts, rams, dies and sow blocks; Wheeling Mold & Foundry Co., Wheeling, W. Va.

CRUCIBLE STAINLESS IRON; No. 12 (chromium 11.5 to 13 per cent) No. 16 (chromium 15 to 18 per cent); No. 18 (chromium 18 to 23 per cent); No. 24 (chromium 24 to 30 per cent); corrosion-resistant; Crucible Steel Co. of America, New York.

CRUCIBLE STAINLESS STEELS; Grade A (chromium 12.5 to 14 per cent); Grade B (chromium 16 to 17 per cent); corrosion-resistant; Crucible Steel Co. of America, New York.

CUYO; stainless and heat-resisting steels in sizes from 1/16-inch round up to 2½-inch rounds, inclusive in all analyses; also special shapes, squares, flats, etc.; Cuyahoga Steel & Wire Co., P. O. Station D, Cleveland.

CYCLOPS No. 17; a noncorrosive steel for pump rods, still plugs, thermocouple wells, turbine blades, etc.; chromium 8, nickel 20 per cent; Cyclops Steel Co., Titusville, Pa.

CYCLOPS ORION; chrome-vanadium steel for machine parts; Cyclops Steel Co., Titusville, Pa.

CYCLOPS STAINLESS; Grade "A" (chromium 12.50, nickel 0.50 maximum); Grade "B" (chromium 17, nickel 0.50 maximum); Cyclops Steel Co., Titusville, Pa.

D

DARWIN COBALT MAGNET; a steel for permanent magnets containing cobalt; Darwin & Milner, Inc., Cleveland.

DAVIS METAL; a corrosion-resisting iron; for valves and fittings; carbon and silicon 0.5, manganese 1.5, nickel 29, iron 2, copper 67 per cent; Chapman Valve Mfg. Co., Indian Orchard, Mass.

DEFIHEAT RUSTLESS IRON; a heat and corrosion-resisting alloy; chrominum 25 to 30, manganese under 0.05, carbon under 0.25 and nickel under 0.5 per cent; Rustless Iron Corporation of America, Baltimore, Md.

DEFIRUST RUSTLESS IRON; a corrosion-resisting alloy; chromium 12 to 14; manganese under 0.5; carbon under 0.1 and nickel under 0.5 per cent; Rustless Iron Corporation of America, Baltimore, Md.

DEFISTAIN RUSTLESS IRON; a heat and corrosion-resisting alloy; chromium 17 to 19, nickel 7 to 10, manganese under 0.5, carbon 0.2 per cent; Rustless Iron Corp. of America, Baltimore, Md.

DELHI A; a heat-resisting alloy; chromium 16.5 to 18.5, silicon 0.75 and carbon 0.1 per cent maximum; Associated Alloy Steel Co. Inc., Cleveland.

DELHI HARD; a corrosion-resisting alloy in the form of bars; chromium 16.5 to 18, carbon 1 to 1.1, silicon 0.75 to 1; Associated Alloy Steel Co. Inc., Cleveland.

Montreal, Que., Spang-Chalfant & Co. Inc., Pittsburgh; St. Joseph Electric Steel Castings Co., St. Joseph

chromium), "N" (21 to 24 chromium, 12 nickel), "18-8" (18 chromium, 8 nickel), "15-35" (15 chromium, 35 per cent nickel; for resisting corrosion; The Duraloy Co., Pittsburgh.

DURBAR; a high lead bronze bearing metal; Buffalo Bronze Die Cast Corp., Buffalo, N. Y.

DUREX; a bronze of the copper-tin series; porous to about 25 per cent by volume; Moraine Products Co., Dayton, O.

DURIMET; grade L in sheets, bars and rods; nickel 22.5, chromium, 19.25, silicon 3.25, molybdenum 1.10, copper 1.10 and carbon .25 per cent; cast grade has nickel 34, chromium 12.50, silicon 3.50, molybdenum 2.5, copper 1.25 and carbon .25 per cent; Duriron Co. Inc., Dayton, Ohio.

DURIRON; an acid-resisting, high silicon iron; Duriron Co. Inc., Dayton, Ohio.

DUTCH BOY BABBITT; for bearings; analysis varies for different applications; National Lead Co., New York.

E

EIS 71; an electric induction furnace alloy steel for shear knives; Heppenstall Co., Pittsburgh.

ELCOMET; a nickel-chromium steel alloy of high-silicon content; resistant to corrosion; for spinner heads, valves, pumps, etc.; La Bour Co. Inc., Elkhart, Ind.

ELECTROMET; a line of ferrous alloys of varying analyses; Electro-Metallurgical Sales Corp., New York.

ELKONITE; a hard, wear-resistant tungsten copper alloy of good electrical conductivity; for electrical contacts, motor bearings, third rail shoes, etc.; Elkon Division, P. R. Mallory & Co. Inc., Indianapolis, Ind.

ELVERITE; special castings with wear-resisting qualities; for tube mill linings, wheels, jaw crushers, sprockets, etc.; Fuller Lehigh Co., Fullerton, Pa.

ENDURIA; a special carbon spring steel; Bethlehem Steel Co., Bethlehem, Pa.

ENDURO A; resistant to heat; 18 per cent straight chromium; Babcock & Wilcox Tube Co., New York.

ENDURO AA; a heat-resisting alloy; chromium 16.5 to 18.5, silicon 0.75 and carbon 0.1 per cent maximum; Republic Steel Corp., Youngstown, O.

ENDURO KA2 (18 chromium, 8 nickel), AA (18 chromium), S and S-15 (13 per cent chromium); stainless irons resistant to heat and corrosion; Republic Steel Corp., Youngstown, O.

ERMALITE; a wear resisting alloy iron; for gears, wearing plates, friction drums and other parts subject to high stresses or wear. Erie Malleable Iron Co., Erie, Pa.

EVANSTEEL; a nickel-chrome alloy possessing wear-resisting qualities; for tractors, wheel castings, switch points, dies, ball mills, oil-pipe clamps, wheels, etc.; Chicago Steel Foundry Co., Chicago.

EVERBRITE; No. 90 (nickel 35, copper 60 per cent), for valves and chemical plants; No. 92 (nickel 35, copper 58 per cent), for high-pressure steam valves, chemical plants; Curtis Bay Copper & Iron Works, Baltimore.

EVERDUR, an acid-resisting alloy; silicon 3, manganese 1, copper 96 per cent; American Brass Co., Waterbury, Conn.

EVERUN; a phosphor bronze for use as a bearing metal; copper 75, lead 15, zinc 3 and tin 7 per cent; Buffalo Bronze Die Cast Corp., Buffalo, N. Y.

F

FAHRALLOY; contains from 28 chromium without nickel to 18 chromium and 70 per cent nickel for all heat and corrosion-resisting purposes; Southern manganese division of American Manganese Steel Co., St. Louis.

FAHRITE; an alloy with heat-resisting qualities; for stirring arms, pots, retorts and furnace parts; the Ohio Steel Foundry Co., Springfield, O.

FARRELL'S 85; specially processed steel for resisting wear and abrasion and possessing high strength, toughness and rigidity; Farrell-Cheek Steel Foundry, Sandusky, O.

FIREARMOR; an alloy resistant to high temperatures and abrasion; nickel 60, chromium 20, iron 10, manganese 1.75, and carbon 0.5 per cent. Also Alloys No. 48 and No. 55, for similar purposes; Michiana Products Corp., Michigan City, Ind.

FIREX; a special alloy steel containing nickel and chromium; used for clutch

Iron
.75, and silic
Corp., Rockfo

HALCOMB N. C
rosion-resistant
racuse, N. Y.
HALCOMB REZ
made in vari
and heat-resi
Co., Syracuse,
HALCOMB STA
for free machin
chrome 12 per
to 13 per cent;
per cent; No.
cent; No. 24 ch
Halcomb Steel
HALCOMB STAI
A, chrome 12.5
per cent; Halco
N. Y.
HARDTEM; a c
num vanadium
Heppenstall Co
HASTELLOY; A
num 20 per cen
molybdenum a
90, copper 3,
and silicon plu
A, forgeable;
alloys resistant
and corrosion
Kokomo, Ind.
HAYSTELLITE;
bide used as
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and various t
the oil and m
grades are us
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HIOLOY; Grade
sion), Grade S
and abrasion),
to corrosion),
ry Co., Lima
HIPERNICK; a
for electrical us
per cent each;
Chicago.
HOYT BABBIT
ings; analysis v
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York.
HUBBARD SPE
steel; for wear-
cellaneous cast
& Steel Found
Ind.
HYB-LUM; a cor
purpose alloy c
per cent chrom
metals of the
pure aluminum;
Jackson, Mich.
HYBNICKEL, "A
and "S"; a seri
alloys for heat
Victor Hybinett
HYLASTIC; grea
increase in wei
ganese 1.50, ph
.05; American
cago.
HY-SPEED; for
bars; copper
per cent; Buck
Cleveland.
HY-TEN; alloy st
from .1 to 1 pe
ened, oil or w
tions; Wheelock
Cambridge, Mass
HY-TEN-SL; a
for engineering
Manganese Bro
Philadelphia, Pa

IDEOR; a special
sten and chrom
Inc., Cleveland.
ILLIUM; a heat
alloy containing
7 copper, 4 mol
1 silicon and 1
gess-Parr Co.,

This
the Jan
co-oper
ther ad

icon 2 per cent,
ford, Ill.

H

C. R. 238; heat and cor-
nt; Halcomb Steel Co., Sy-
.
EZISTAL; stainless steels
arious grades; corrosion
esistant; Halcomb Steel
se, N. Y.
TAINLESS IRONS; FM2
chining, corrosion resistant,
er cent; No. 12 chrome 12
nt; No. 16 chrome 15 to 16
o. 18 chrome 18 to 20 per
chrome 24 to 26 per cent;
eel Co., Syracuse, N. Y.
TAINLESS STEELS; Grade
12.5 per cent; B, chrome 17
alcomb Steel Co., Syracuse,

a chrome nickel molybde-
ium die block, heat treated;
Co., Pittsburgh.
Y; A (nickel 60, molybde-
r cent), C (iron, chromium,
m and nickel), D (nickel
3, aluminum 1.5 per cent
n plus or minus 10); grade
ble; C and D, castings only
stant to high temperatures
sion; Haynes Stellite Co.,
Ind.
ITE; a cast tungsten car-
as a diamond substitute
etting oil well drilling tools
us types of core drills in
d mining industries; other
e used for wire drawing
cutting tools; Haynes Stel-
Kokomo, Ind.
rade W (resistant to abra-
de SW (resistant to shock
sion), Grade CR (resistant
on), The Ohio Steel Found-
ima and Springfield, O.
; a high-permeability alloy;
al usage; nickel and iron, 50
each; Western Electric Co.,

BITT METAL; for bear-
ysis varies according to ap-
National Lead Co., New

SPECIAL; a nickel-chrome
vear-resisting rolls and mis-
castings; Continental Roll
oundry Co., East Chicago,

a corrosion-resisting, general
loy containing from 2 to 2½
hromium, nickel and other
the chromium group; and
num; Sheet Aluminum Corp.,
ich.
L, "A," "B," "C," "D," "R"
a series of nickel-chromium
heat and acid resistance;
inette, Wilmington, Del.
greater strength with no
weight; carbon .35, man-
0, phosphorus .05, sulphur
ican Steel Foundries, Chi-

for bushings, bearings and
per 88, tin 7 and zinc 2
Buckeye Brass & Mfg. Co.,

loy steels ranging in carbon
1 per cent; for case hard-
or water-hardened applica-
eelock Lovejoy & Co. Inc.,
Mass.
; a high-strength bronze
ering purposes; American
Bronze Co., Holmesburg,
a, Pa.

I

ecial alloy containing tung-
romium; Darwin & Milner,
and.
heat and corrosion-resisting
ning 60 nickel, 25 chromium,
molybdenum, 2 manganese,
d 1 per cent tungsten; Bur-
Co., Moline, Ill.

KLEENKUT; a high carbon high chrome nickel molybdenum steel used for shearing sheets and tin plate; Heppenstall Co., Pittsburgh.

KONEL; nickel 73, cobalt 17.5, iron 6.5, titanium 2.5 and manganese 0.2 per cent; an alloy in the form of bars, sheets and wire resistant to high temperatures; Westinghouse Research Laboratories, East Pittsburgh, Pa.

L

LUBRICO; for bearings, bushings and bars; copper 75, lead 20 and tin 5 per cent; Buckeye Brass & Mfg. Co., Cleveland.

LUCERO; corrosion resistant; copper 68, nickel 30, and iron 2 per cent; Driver-Harris Co., Harrison, N. J.

LUMEN; Alloy No. 00A copper 80, tin 20 per cent and trace of phosphorus; No. OOC, copper 84, tin 16 per cent and trace of phosphorus; No. 1, copper 88, tin 10 and zinc 2 per cent; No. 4, copper 80, tin 10, lead 10 per cent, and trace of phosphorus; No. 5, copper 85, tin 5, lead 5, zinc 5 and trace of phosphorus; No. 6, copper 78, tin 8, lead 14 and trace of phosphorus; No. 9, copper 57, tin 0.75, zinc 40, iron 1, aluminum 0.5 and manganese 0.25 per cent; No. 11C, copper 89, iron 1 and aluminum 10 per cent; No. 14, copper 90, tin 6.5, lead 1.5, and zinc 2 per cent; No. 15, copper 88.5, tin 11, lead 0.25 and phosphorus 0.25 per cent; No. 15A, copper 88, tin 10, lead 1.5, phosphorus a trace, and nickel 0.5 per cent; No. 27, copper 79.75, iron 6, aluminum 10.75 and manganese 3.5 per cent; No. 48, copper 84, tin 10, lead 2.5 and nickel 3.5 per cent; No. 54, copper 85, tin 10 and lead 5 per cent; Lumen Bearing Co., Buffalo.

LUMEN BRONZE; copper 10, zinc 86, and aluminum 4 per cent; Lumen Bearing Co., Buffalo.

LYNITE; aluminum alloy with high thermal conductivity for pistons and connecting rods; Aluminum Company of America, Pittsburgh.

M

MACKENITE METAL; heat-resistant; for retorts, annealing pots, cylinders and lead pan castings; Duncan Mackenzie's Sons Co., Trenton, N. J.

MANGANIN; high copper alloy containing manganese 10, nickel 2.5 per cent and balance copper; Driver-Harris Co., Harrison, N. J.

MANGANO; carbon 0.95, manganese 1.60, chromium 0.20; used where nonshrinking, oil quenching steel is required; Latrobe Electric Steel Co., Latrobe, Pa.

MARTIN STEEL; abrasive resistant; air hardening tool steel castings; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Detroit Alloy Steel Co., Detroit.

MAX-EL MACHINERY STEELS; used in various structural parts of all types of machinery; graded according to purpose, plain and alloy types; carbon ranges from .2 to .8 to suit application; Crucible Steel Co. of America, New York.

MAXTENSILE; a nickel iron used for hydraulic castings, sliding parts, spindles, couplings, sprockets, mill rolls, etc.; Farrel-Birmingham Co., Ansonia, Conn.

MAYARI "A"; a chrome nickel steel; for bolts, auto parts, axles, tools, etc.; Bethlehem Steel Co., Bethlehem, Pa.

MEEHANITE METAL; carbon 2.40 to 3, silicon .90 to 2.50, phosphorus 0.1 to 0.2, sulphur under .05, manganese .25 to 1.25 per cent; a metal resistant to abrasion, heat and corrosion; Ross-Meehan Foundries, Chattanooga, Tenn.

MIDVALE STAINLESS IRON; iron, 85

SUPPLEMENT
to the
September, 1930 Number
of
MACHINE DESIGN

**his list is a complete revision of the original directory which appeared in
January issue of MACHINE DESIGN. It has been brought up-to-date in
peration with producers of alloys, for the assistance of designers. Fur-
additions to the list will be made periodically in this journal.**

chromium 30 per cent), HN (nickel 65 and chromium 18 per cent); resistant to heat and corrosion; Michigan Steel Casting Co., Detroit.

MOLYBDENITE; for pinions and steel castings; Duquesne Steel Foundry Co., Pittsburgh.

MONEL METAL; a corrosion-resisting metal; manganese 2, nickel 67, iron 2, copper 28 per cent; International Nickel Co., New York.

N

NA, NA-1, NA-2, etc., alloy steel, resistant to heat, corrosion and abrasion in varying percentages of nickel and chrome; National Alloy Steel Co., Blawnox, Pa.

NATIONAL; corrosion-resistant light weight alloys; aluminum alloyed with various hardeners to meet special requirements; National Smelting Works, Cleveland.

NEWALOY; resistant to corrosion; 18-8 chromium nickel; Newton Steel Co., Youngstown, Ohio.

NICHROME IV; a heat-resisting alloy; composed of 80 nickel and 20 per cent chromium; Driver-Harris Co., Harrison, N. J.

NICHROME; nickel 60, iron 24, chromium 12, carbon 0.1 per cent; an alloy in the form of bars, sheets, tubing and wire; resistant to high temperatures; Driver-Harris Co., Harrison, N. J.

NIROSTA; a nonrusting steel; chromium 18 and nickel 8 per cent; Acme Steel Co., Chicago; American Forge Co., Chicago; Associated Alloy Steel Co. Inc., Cleveland; Babcock & Wilcox Tube Co., New York; Bacon & Mateson Forge Co., Seattle; Calorizing Co., Pittsburgh; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Nicetown, Philadelphia; Cleveland Alloy Products, Cleveland; Crucible Steel Co. of America, New York; Detroit Seamless Steel Tubes Co., Detroit; Henry Disston & Sons, Inc., Tacony, Philadelphia; Driver-Harris Co., Tacony, Philadelphia; Duriron Co., Dayton, O.; Electric Steel Foundry Co., Portland, Ore.; A. Finkl & Sons Co., Chicago; Firth Sterling Steel Co., McKeesport, Pa.; General Alloys Co., Boston; Globe Steel Tube Co., Milwaukee; Griffin Mfg. Co., Erie, Pa.; Heppenstall Co., Pittsburgh; Lukens Steel Co., Coatesville, Pa.; Michiana Products Corp., Michigan City, Ind.; Milwaukee Steel Foundry Co., Milwaukee; Monarch Foundry Co., Stockton, Calif.; Morris & Bailey Division, American Steel & Wire Co., Pittsburgh; Newton Steel Co., Youngstown, O., Ohio Seamless Tube Co., Shelby, O.; Pacific Foundry Co. Ltd., San Francisco; Pennsylvania Forge Corp., Tacony, Philadelphia; Pittsburgh Steel Co., Pittsburgh; Republic Steel Corp., Youngstown, O.; Shawinigan Stainless Steel & Alloys Ltd., Montreal, Que.; Spang-Chalfant & Co. Inc., Pittsburgh; St. Joseph Electric Steel Castings Co., St. Joseph, Mich.; Standard Alloy Co. Inc., Cleveland; Stanley Works, New Britain, Conn.; Summerill Tubing Co., Bridgeport, Conn.; Wm. J. Sweet Foundry, Irvington, N. J.; Symington Co., New York; Taylor Wharton Iron & Steel Co., High Bridge, N. J.; Texas Electric Steel Castings Co., Houston, Tex.; the Wallingford Steel Co., Wallingford, Conn.; Warman Steel Casting Co., Ltd., Los Angeles; Washington Iron Works, Buffalo; West Steel Casting Co., Cleveland.

NITRALLOY; a chromium-molybdenum-aluminum steel capable of developing extreme hardness through nitriding; Republic Steel Corp., Youngstown, O.; Associated Alloy Steel Co. Inc., Cleveland; and Crucible Steel Co. of America, New York.

NOGROTH; resistant to heat and abrasion; alloy iron, nickel and chrome; The Q & C Co., New York.

NONCORRODITE; chromium steel castings; Millbury Steel Foundry Co., Millbury, Mass.

P

PERLIT; a pearlitic cast iron manufactured under German patents; for brake drums, winch heads, clutch plates and machine frames; has high tensile strength; Davis & Thomas Co., Catasauqua, Pa.

PERMALLOY; a high-permeability alloy for electrical usage; nickel 78, iron 22 per cent; Western Electric Co., Chicago.

PLYMITE; a tungsten alloy resistant

forgings ,sheet, plate or bar stock; high resistance to oxidation; General Alloys Co., Boston.

R

RCF; a chrome-nickel alloy possessing wear-resisting qualities; George H. Smith Steel Casting Co., Milwaukee.

REACTAL; heat resistant; contains nickel and chromium; Darwin & Milner Inc., Cleveland.

RENYX ALUM.; resistant to corrosion; nickel 4, copper 4, silicon .5 and aluminum 91.5 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RENYX AZN; corrosion-resisting and fine finish; copper 3, aluminum 4, manganese .1 and zinc 92.9 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RESILLA; a special analysis silicomanganese spring steel; Bethlehem Steel Co., Bethlehem, Pa.

RESISTAC; an acid-resisting metal composed of 90 copper, 9 aluminum, and 1 per cent iron; American Manganese Bronze Co., Philadelphia, Pa.

REZISTAL KA-2; made in various grades; chromium nickel steels, resistant to corrosion and high temperature; Crucible Steel Co. of America, New York.

RITA; chrome nickel steels for high strength, superior wearing qualities and toughness; resistant to heat and corrosion; Cannon-Stein Steel Corp., Syracuse, N. Y.

ROL-MAN MANGANESE STEEL; manganese 11 to 14, carbon 1 to 1.4 per cent; a manganese steel in bar, sheet and wire form; resistant to abrasion; Manganese Steel Forge Co., Philadelphia, Pa.

RUSELITE; corrosion-resistant, high strength aluminum alloy; aluminum 94, copper 4 per cent and balance chromium and molybdenum; Ruselite Corp., Milwaukee.

S

SABECO; for use as bearings and bushings; copper, tin and lead, specially processed; Fredericksen Co., Saginaw, Mich.

SAMSON; a chrome-nickel steel for
heat-treated machine parts; Carpen-
ter Steel Co., Reading, Pa.
SEYMOURITE; resistant to corrosion;
copper 64, nickel 18 and zinc 18 per
cent; Seymour Mfg. Co., Seymour,
Conn.
SILCROME; heat-resisting valve steel;
varying analyses; Ludlum Steel Co.,
Watervliet, N. Y.
SMITHCO DYNAMO; an alloy stee
possessing high magnetic permeabil
ity; George H. Smith Steel Castin
Co., Milwaukee.
SPECIAL DEFIRUST RUSTLES
IRON; an alloy resistant to corrosio
and abrasion; chromium 16 to 18
manganese under 0.5, carbon unde
0.1 and nickel under 0.5; Rustles
Iron Corporation of America, Balt
more, Md.
STANDARDALLOY; a chromiun
nickel alloy (20 to 60 nickel, 16 to 2
per cent chromium); for heat-resis
ing purposes; Standard Alloy C
Inc., Cleveland.
STELLITE; an abrasion-resisting all
for hard facing of drills, etc.; coba
40 to 80, tungsten 0 to 25, chromiu
20 to 35, and carbon 0.75 to 2.5 p
cent; Haynes Stellite Co., Kokon
Ind.
STERLING NIROSTA; a stainless r
sisting steel (carbon 0.15 and chr
mium 18.0 per cent) in strip, she
tube form and for articles to be h
forged or cold pressed; Firth-Ste
ing Steel Co., McKeesport, Pa.
STERLING STAINLESS STEE
Types "A," "B," "T," "MG"; ch
mium steels with chromium fr
12.50 in "T" to 19.00 per cent
"MG"; for cutlery, surgical and d
tal instruments, general machin
parts, etc.; Firth-Sterling Steel C
McKeesport, Pa.
SUMET BISON; bronze of high l
content, resistant to friction and
pansion; Sumet Corp., Buffalo, N.
SUPERTEMP; an alloy steel hav
high tensile strength at high temp
ature; suitable for bolts and st
for reaction chambers, cracking st
superheaters, etc.; Bethlehem S
Co., Bethlehem, Pa.
SWEETALLOY; No. 16, a stainless
for screw plugs, valves, etc.; No.
a high-chromium-nickel iron,
resisting; No. 18, a high nickel-c
mium iron, corrosion-resisting;
19, a high-chromium iron, abra
resisting; No. 20 a high-nickel h

nium 19 to 21 per cent, for op-
can be rolled,

drels, machine parts, press tools, etc.; The Kinite Corp., Milwaukee.

KLEENKUT; a high carbon high chrome nickel molybdenum steel used for shearing sheets and tin plate; Heppenstall Co., Pittsburgh.

KONEL; nickel 73, cobalt 17.5, iron 6.5, titanium 2.5 and manganese 0.2 per cent; an alloy in the form of bars, sheets and wire resistant to high temperatures; Westinghouse Research Laboratories, East Pittsburgh, Pa.

L

LUBRICO; for bearings, bushings and bars; copper 75, lead 20 and tin 5 per cent; Buckeye Brass & Mfg. Co., Cleveland.

LUCERO; corrosion resistant; copper 68, nickel 30, and iron 2 per cent; Driver-Harris Co., Harrison, N. J.

LUMEN; Alloy No. 00A copper 80, tin 20 per cent and trace of phosphorus; No. OOC, copper 84, tin 16 per cent and trace of phosphorus; No. 1, copper 88, tin 10 and zinc 2 per cent; No. 4, copper 80, tin 10, lead 10 per cent, and trace of phosphorus; No. 5, copper 85, tin 5, lead 5, zinc 5 and trace of phosphorus; No. 6, copper 78, tin 8, lead 14 and trace of phosphorus; No. 9, copper 57, tin 0.75, zinc 40, iron 1, aluminum 0.5 and manganese 0.25 per cent; No. 11C, copper 89, iron 1 and aluminum 10 per cent; No. 14, copper 90, tin 6.5, lead 1.5, and zinc 2 per cent; No. 15, copper 88.5, tin 11, lead 0.25 and phosphorus 0.25 per cent; No. 15A, copper 88, tin 10, lead 1.5, phosphorus a trace, and nickel 0.5 per cent; No. 27, copper 79.75, iron 6. aluminum 10.75 and manganese 3.5 per cent; No. 48, copper 84, tin 10, lead 2.5 and nickel 3.5 per cent; No. 54, copper 85, tin 10 and lead 5 per cent; Lumen Bearing Co., Buffalo.

LUMEN BRONZE; copper 10, zinc 86, and aluminum 4 per cent; Lumen Bearing Co., Buffalo.

LYNITE; aluminum alloy with high thermal conductivity for pistons and connecting rods; Aluminum Company of America, Pittsburgh.

M

MACKENITE METAL; heat-resistant; for retorts, annealing pots, cylinders and lead pan castings; Duncan Mackenzie's Sons Co., Trenton, N. J.

MANGANIN; high copper alloy containing manganese 10, nickel 2.5 per cent and balance copper; Driver-Harris Co., Harrison, N. J.

MANGANO; carbon 0.95, manganese 1.60, chromium 0.20; used where nonshrinking, oil quenching steel is required; Latrobe Electric Steel Co., Latrobe, Pa.

MARTIN STEEL; abrasive resistant; air hardening tool steel castings; chromium 12 to 14, cobalt .7 to .9, and carbon 1.5 to 1.6 per cent; Detroit Alloy Steel Co., Detroit.

MAX-EL MACHINERY STEELS; used in various structural parts of all types of machinery; graded according to purpose, plain and alloy types; carbon ranges from .2 to .8 to suit application; Crucible Steel Co. of America, New York.

MAXTENSILE; a nickel iron used for hydraulic castings, sliding parts, spindles, couplings, sprockets, mill rolls, etc.; Farrel-Birmingham Co., Ansonia, Conn.

MAYARI "A"; a chrome nickel steel; for bolts, auto parts, axles, tools, etc.; Bethlehem Steel Co., Bethlehem, Pa.

MEEHANITE METAL; carbon 2.40 to 3, silicon .90 to 2.50, phosphorus 0.1 to 0.2, sulphur under .05, manganese .25 to 1.25 per cent; a metal resistant to abrasion, heat and corrosion; Ross-Meehan Foundries, Chattanooga, Tenn.

MIDVALE STAINLESS IRON; iron, 85

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the
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E DESIGN

e original directory which appeared in
GN. It has been brought up-to-date in
for the assistance of designers. Fur-
e periodically in this journal.

Steel Castings Co., Milwaukee.

MISCO; Standard (nickel 35 and chromium 15 per cent), C (nickel 9 and chromium 30 per cent), HN (nickel 65 and chromium 18 per cent); resistant to heat and corrosion; Michigan Steel Casting Co., Detroit.

MOLYBDENITE; for pinions and steel castings; Duquesne Steel Foundry Co., Pittsburgh.

MONEL METAL; a corrosion-resisting metal; manganese 2, nickel 67, iron 2, copper 28 per cent; International Nickel Co., New York.

N

NA, NA-1, NA-2, etc., alloy steel, resistant to heat, corrosion and abrasion in varying percentages of nickel and chrome; National Alloy Steel Co., Blawnox, Pa.

NATIONAL; corrosion-resistant light weight alloys; aluminum alloyed with various hardeners to meet special requirements; National Smelting Works, Cleveland.

NEWALOY; resistant to corrosion; 18-8 chromium nickel; Newton Steel Co., Youngstown, Ohio.

NICHROME IV; a heat-resisting alloy; composed of 80 nickel and 20 per cent chromium; Driver-Harris Co., Harrison, N. J.

NICHROME; nickel 60, iron 24, chromium 12, carbon 0.1 per cent; an alloy in the form of bars, sheets, tubing and wire; resistant to high temperatures; Driver-Harris Co., Harrison, N. J.

NIROSTA; a nonrusting steel; chromium 18 and nickel 8 per cent; Acme Steel Co., Chicago; American Forge Co., Chicago; Associated Alloy Steel Co. Inc., Cleveland; Babcock & Wilcox Tube Co., New York; Bacon & Mateson Forge Co., Seattle; Calorizing Co., Pittsburgh; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Nicetown, Philadelphia; Cleveland Alloy Products, Cleveland; Crucible Steel Co. of America, New York; Detroit Seamless Steel Tubes Co., Detroit; Henry Disston & Sons, Inc., Tacony, Philadelphia; Driver-Harris Co., Tacony, Philadelphia; Duriron Co., Dayton, O.; Electric Steel Foundry Co., Portland, Ore.; A. Finkl & Sons Co., Chicago; Firth Sterling Steel Co., McKeesport, Pa.; General Alloys Co., Boston; Globe Steel Tube Co., Milwaukee; Griffin Mfg. Co., Erie, Pa.; Heppenstall Co., Pittsburgh; Lukens Steel Co., Coatesville, Pa.; Michiana Products Corp., Michigan City, Ind.; Milwaukee Steel Foundry Co., Milwaukee; Monarch Foundry Co., Stockton, Calif.; Morris & Bailey Division, American Steel & Wire Co., Pittsburgh; Newton Steel Co., Youngstown, O., Ohio Seamless Tube Co., Shelby, O.; Pacific Foundry Co. Ltd., San Francisco; Pennsylvania Forge Corp., Tacony, Philadelphia; Pittsburgh Steel Co., Pittsburgh; Republic Steel Corp., Youngstown, O.; Shawinigan Stainless Steel & Alloys Ltd., Montreal, Que.; Spang-Chalfant & Co. Inc., Pittsburgh; St. Joseph Electric Steel Castings Co., St. Joseph, Mich.; Standard Alloy Co. Inc., Cleveland; Stanley Works, New Britain, Conn.; Summerill Tubing Co., Bridgeport, Conn.; Wm. J. Sweet Foundry, Irvington, N. J.; Symington Co., New York; Taylor Wharton Iron & Steel Co., High Bridge, N. J.; Texas Electric Steel Castings Co., Houston, Tex.; the Wallingford Steel Co., Wallingford, Conn.; Warman Steel Casting Co., Ltd., Los Angeles; Washington Iron Works, Buffalo; West Steel Casting Co., Cleveland.

NITRALLOY; a chromium-molybdenum-aluminum steel capable of developing extreme hardness through nitriding; Republic Steel Corp., Youngstown, O.; Associated Alloy Steel Co. Inc., Cleveland; and Crucible Steel Co. of America, New York.

NOGROTH; resistant to heat and abrasion; alloy iron, nickel and chrome; The Q & C Co., New York.

NONCORRODITE; chromium steel castings; Millbury Steel Foundry Co., Millbury, Mass.

P

PERLIT; a pearlitic cast iron manufactured under German patents; for brake drums, winch heads, clutch plates and machine frames; has high tensile strength; Davis & Thomas Co., Catasauqua, Pa.

PERMALLOY; a high-permeability alloy for electrical usage; nickel 78, iron 22 per cent; Western Electric Co., Chicago.

PLYMITE; a tungsten alloy resistant

chromium 19 to 21 per cent, for operation up to 2200 degrees Fahr.; Grade A+, obtainable in castings, forgings ,sheet, plate or bar stock; high resistance to oxidation; General Alloys Co., Boston.

R

RCF; a chrome-nickel alloy possessing wear-resisting qualities; George H. Smith Steel Casting Co., Milwaukee.

REACTAL; heat resistant; contains nickel and chromium; Darwin & Milner Inc., Cleveland.

RENYX ALUM.; resistant to corrosion; nickel 4, copper 4, silicon .5 and aluminum 91.5 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RENYX AZN; corrosion-resisting and fine finish; copper 3, aluminum 4, manganese .1 and zinc 92.9 per cent; Allied Die-Casting Corp., Long Island City, N. Y.

RESILLA; a special analysis silico-manganese spring steel; Bethlehem Steel Co., Bethlehem, Pa.

RESISTAC; an acid-resisting metal composed of 90 copper, 9 aluminum, and 1 per cent iron; American Manganese Bronze Co., Philadelphia, Pa.

REZISTAL KA-2; made in various grades; chromium nickel steels, resistant to corrosion and high temperature; Crucible Steel Co. of America, New York.

RITA; chrome nickel steels for high strength, superior wearing qualities and toughness; resistant to heat and corrosion; Cannon-Stein Steel Corp., Syracuse, N. Y.

ROL-MAN MANGANESE STEEL; manganese 11 to 14, carbon 1 to 1.4 per cent; a manganese steel in bar, sheet and wire form; resistant to abrasion; Manganese Steel Forge Co., Philadelphia, Pa.

RUSELITE; corrosion-resistant, high strength aluminum alloy; aluminum 94, copper 4 per cent and balance chromium and molybdenum; Ruselite Corp., Milwaukee.

S

SABECO; for use as bearings and bushings; copper, tin and lead, specially processed; Fredericksen Co., Saginaw, Mich.

SAMSON; a chrome-nickel steel for heat-treated machine parts; Carpenter Steel Co., Reading, Pa.

SEYMOURITE; resistant to corrosion; copper 64, nickel 18 and zinc 18 per cent; Seymour Mfg. Co., Seymour, Conn.

SILCROME; heat-resisting valve steel; varying analyses; Ludlum Steel Co., Watervliet, N. Y.

SMITHCO DYNAMO; an alloy steel possessing high magnetic permeability; George H. Smith Steel Casting Co., Milwaukee.

SPECIAL DEFIRUST RUSTLESS IRON; an alloy resistant to corrosion and abrasion; chromium 16 to 18; manganese under 0.5, carbon under 0.1 and nickel under 0.5; Rustless Iron Corporation of America, Baltimore, Md.

STANDARDALLOY; a chromium-nickel alloy (20 to 60 nickel, 16 to 25 per cent chromium); for heat-resisting purposes; Standard Alloy Co., Inc., Cleveland.

STELLITE; an abrasion-resisting alloy for hard facing of drills, etc.; cobalt 40 to 80, tungsten 0 to 25, chromium 20 to 35, and carbon 0.75 to 2.5 per cent; Haynes Stellite Co., Kokomo, Ind.

STERLING NIROSTA; a stainless resisting steel (carbon 0.15 and chromium 18.0 per cent) in strip, sheet, tube form and for articles to be hot forged or cold pressed; Firth-Sterling Steel Co., McKeesport, Pa.

STERLING STAINLESS STEELS, Types "A," "B," "T," "MG"; chromium steels with chromium from 12.50 in "T" to 19.00 per cent in "MG"; for cutlery, surgical and dental instruments, general machinery parts, etc.; Firth-Sterling Steel Co., McKeesport, Pa.

SUMET BISON; bronze of high lead content, resistant to friction and expansion; Sumet Corp., Buffalo, N. Y.

SUPERTEMP; an alloy steel having high tensile strength at high temperature; suitable for bolts and studs for reaction chambers, cracking stills, superheaters, etc.; Bethlehem Steel Co., Bethlehem, Pa.

SWEETALLOY; No. 16, a stainless iron for screw plugs, valves, etc.; No. 17, a high-chromium-nickel iron, acid resisting; No. 18, a high nickel-chromium iron, corrosion-resisting; No. 19, a high-chromium iron, abrasion resisting; No. 20 a high-nickel high-

can be rolled, drawn, forged or shaped; for wire screens, welding rod, etc.; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TIMAXX; heat-resisting manganese steel; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TISCO; manganese steel castings; 12 per cent manganese; for severe service in wearing parts of excavating, crushing machinery, etc.; Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

TOBIN BRONZE; a corrosion-resisting metal; for pump shafts, propeller blades, etc.; copper 60, zinc 39.25, tin 0.75 per cent; American Brass Co., Waterbury, Conn.

TONCAN; an iron alloyed with copper and molybdenum; corrosion resistant; Republic Steel Corp., Youngstown, O., Babcock & Wilcox Tube Co., New York.

TOPHET A; a corrosive resisting alloy; nickel 80, chromium 20 per cent; Grade "C," an alloy in the form of bars, sheets and wire; nickel 60, chromium 12 per cent and iron; resistant to high temperatures and corrosion; Gilby Wire Co., Newark, N. J.

TUFALOY; an alloy cast steel possessing a high yield point and wear resisting qualities; Fort Pitt Steel Casting Co., McKeesport, Pa.

U

UNILOY; No. 1409, a noncorrosive stainless iron (chromium 12 to 14, carbon 0.1 per cent); No. 1809, a noncorrosive high-chrome stainless iron (chromium 16 to 18, carbon 0.1 per cent); No. 2825, a noncorrosive iron heat resisting to 2000 degrees Fahr. (chromium 28 per cent); Cyclops Steel Co., Titusville, Pa.

UNILOY; No. 1, noncorrosive, heat resisting to 1600 degrees Fahr. (chromium 18, nickel 8 per cent); No. 2, noncorrosive, heat resisting to 1800 degrees Fahr. (chromium 21, nickel 12 per cent); Cyclops Steel Co., Titusville, Pa.

UNIONALOY; an iron base alloy; for mill guides, tube mill plugs, hopper liners; resistant to abrasion; Union Steel Casting Co., Pittsburgh.

UNIVAN; an alloy cast steel; resistant to shock and stress; vanadium 0.16 minimum, phosphorus and sulphur 0.05 per cent maximum; for locomotive frames, wheel centers, crossheads; Union Steel Casting Co., Pittsburgh.

U. S. S. CHROMIUM; grade 18-8, a corrosion and heat-resisting steel, chromium 17 to 19, nickel 7 to 9 per cent; grade 12-14, a corrosion and abrasion-resisting alloy for forgings, chromium 12 to 14 and carbon 10 per cent maximum; grade 16-18, a corrosion and heat-resisting alloy, chromium 16 to 18 and carbon 10 per cent maximum; Illinois Steel Co., Chicago.

V

VASCO; stainless steels; corrosion and heat-resistant; Type A, chromium 14; B, chromium 16.50; I, chromium 14; N, chromium 18 and nickel 8; U, chromium 18, nickel 8, copper 1.5 and molybdenum 1.5 per cent; Vanadium-Alloys Steel Co., Latrobe, Pa.

W

WANDO; an oil-hardening steel; carbon 0.95, manganese 1.05, chromium 0.50, tungsten 0.50 per cent; Cyclops Steel Co., Titusville, Pa.

WEST; "60 Stancast," "75-Hy-Cast," "90-Dura-cast" and "110-Cum-Loy"; special alloy steel castings for a wide diversity of requirements; West Steel Casting Co., Cleveland.

X

X-7; a special alloy to be used where sulphur bearing gases or acids are present; resistant to high temperature; General Alloys Co., Boston.

X-ITE, an alloy for furnace parts and mechanisms operating at elevated temperatures; nickel 37 to 39, chromium 17 to 19 per cent; General Alloys Co., Boston.

Z

ZAMAK; a zinc-base die casting alloy; 4 per cent aluminum, 3 per cent copper, .1 per cent magnesium; balance is zinc; New Jersey Zinc Co., 160 Front street, New York.

ZORITE; nickel 35, iron 17, chromium 15, manganese 1.75, and carbon 0.5 per cent; resistant to abrasion and high temperatures; Michiana Products Corp., Michigan City, Ind.

variables which he may desire to assign. Considering the point where the diagonal strikes the vertical scale as the origin the following equations apply to the respective scales:

$$X = M_1 I \qquad Z = M_3 h^3$$
$$Y = M_2 b \qquad T = M_4 K$$

Distances X, Y, Z and T are taken from the point where the diagonal meets the vertical scale to the point having the assigned value of I, b, h and K respectively. Any value may be assigned to M_1, M_2, M_3 and M_4 to make the scale of the length desired but there must be a certain relationship between these as given by:

$$M_1 = \frac{M_2 M_3}{M_4}$$

In other words we can select values for any three of these M's but when we have them the fourth must be such as to satisfy the above equation. The equations for the scales of the chart shown in Fig. 2 are:

$$X = 0.05I \qquad Z = 0.01h^3$$
$$Y = 1.5b \qquad T = 0.3K$$

In Fig. 3 we have a chart designed for the rapid calculation of the moment of inertia of a circular area about a diameter in the plane of the area and also about an axis through the center of the circle and perpendicular to the plane of the area. Here the basic formula solved is:

$$I = \frac{\pi R^4}{K}$$

This is a three variable formula of the product type and requires a somewhat different type of chart from that previously illustrated. To solve for I on this chart it is only necessary to lay a ruler from the given value of R on the left hand vertical scale through the point on the diagonal line having the proper value of K and read the value of I where the line projected cuts the right hand vertical scale.

Different Values are Given

In order to increase the field of usefulness of this chart two series of values for R and I have been plotted one on each side of the vertical scales. The chart has been so designed that the point on the diagonal representing the value of K remains the same for both sets of values.

The dot-dash lines on the chart illustrate its use. If R is equal to 0.5 inch then a line drawn through the point on the diagonal marked $K = 2$ and extended will cut the I scale at $I = 0.098$ inch^4. If from this same point on the R scale we draw through $K = 4$ we read $I = 0.049$ inch^4. In the same way if we take $R = 1.6$ and draw through $K = 2$ and $K = 4$ we will cut out values of $I = 10.4$ and $I = 5.2$ respectively.

In case the reader desires one of these charts with limits for the variables outside those shown he can obtain it from the basic scale equations:

$$X = M_1 I \qquad Z = L \frac{M_1 \frac{\pi}{K}}{M_1 \frac{\pi}{K} + M_2}$$
$$Y = M_2 R^4$$

In these equations M_1 and M_2 may be given any value which will make the desired length of scale for the value of I and R selected. L is the length of the diagonal from the beginning of the R scale to the beginning of the I scale. In Fig. 3 this is from the top of the left hand line to the bottom of the right hand line. Once M_1, M_2 and L have been assigned values we have simple equations for each scale, that is, the left hand or R scale, the right hand or I scale and the diagonal or K scale. The distance Z is measured along the diagonal from the point where it meets the I scale.

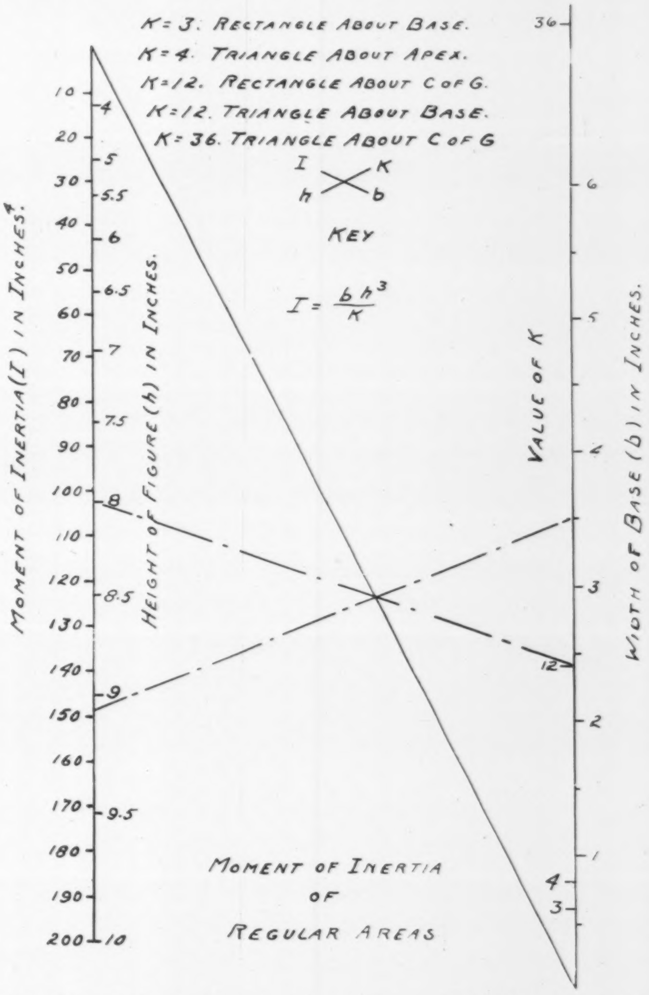


Fig. 2—Chart for finding moments of inertia of triangular and rectangular areas

The equations for the scales shown in Fig. 3

are given below as an aid to the reader who desires to construct such a chart. For the smaller values:

$$X = M_1 I = 100\,I$$

$$Y = M_2 R^4 = 100\,R^4$$

$$Z = L \frac{M_1 \dfrac{\pi}{K}}{M_1 \dfrac{\pi}{K} + M_2} = 10 \frac{100 \dfrac{\pi}{K}}{100 \dfrac{\pi}{K} + 100} = \frac{10\,\pi}{\pi + K}$$

For the larger values:

$$X = 0.5\,I \qquad Z = \frac{10\,\pi}{\pi + K}$$

$$Y = 0.5\,R^4$$

It will be noted that in both cases the equation of the Z scale has the same numerical value.

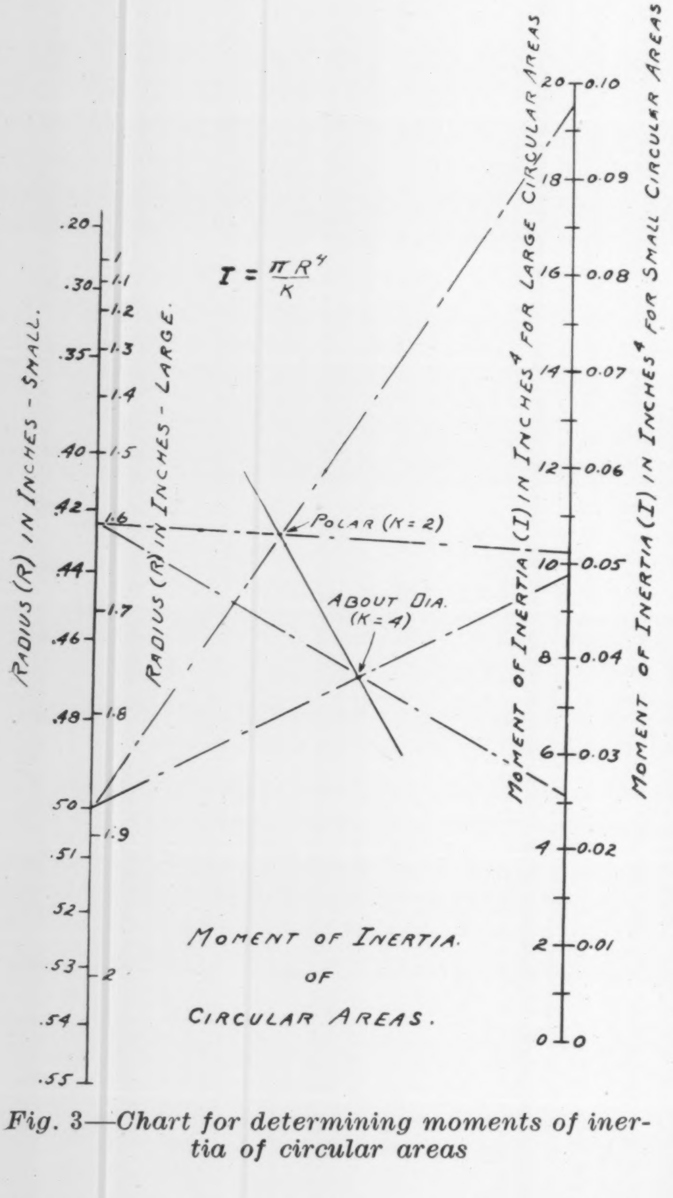


Fig. 3—Chart for determining moments of inertia of circular areas

In determining the moment of inertia of complicated shapes it is necessary to divide the area into regular areas such as rectangles, triangles, circles, etc. Obtain the moment of inertia of each small area about an axis through its center of gravity. When this has been done the moment of inertia of the whole area about any given axis can be obtained by using the formula:

$$I = I_o + AX_o^2$$

in which

I_o = moment of inertia of small regular area about an axis through its center of gravity
A = area of small regular area
X_o = distance from center of gravity of small regular area to given axis about which the moment of inertia of the whole area is desired
I = moment of inertia of small regular area about new axis

When the value of I has been obtained for each small area the sum of them all will give the desired moment of inertia for the irregular area.

The charts given in this article will be found useful in problems involving stress calculations in machine members such as shafts, bolts, supporting arms, frames, etc. where such members are subjected to forces and the value of the section modulus must be known before the maximum fiber stress can be determined.

Slide Rule Device Available

SOME years ago the American Standards association circulated a reprint describing a slide rule device made of cardboard, which permitted draftsmen and machine designers to obtain quickly and accurately the leading dimensions of bolts, nuts, and associated facts such as tap drill diameter, cross sectional area, etc., without running the risk of error which accompanies the taking of such dimensions from a printed table in the customary way. This device, believed to have been first published and used in Switzerland to record basic dimensions of the Swiss national standard for bolts, nuts, washers, and thread characteristics for Whitworth threaded products, now also is being distributed by the Belgian firm, Messrs. Societe Anonyme Gilsoco, of La Croyere, Belgium. The American Standards association will lend a specimen slide rule of this type for examination to any sustaining member interested.

To Give Graduate Courses

Courses for graduate students will be included in the curriculum of Stevens Institute of Technology during the academic year 1930-31 for the first time in the 60 year history of the institution. Stevens heretofore has offered a general unspecialized course in engineering and has given only the undergraduate degree in a course. Since the inauguration of President Harvey N. Davis, a faculty committee has been investigating the field of graduate instruction.

How Design Affects Sales

By John D. Rauch

FORMERLY machinery could be sold if it functioned, no matter what it weighed or how crude or unattractive the design. But today all buyers of machinery and equipment, whether they be purchasing agents of large corporations or the small independent buyers, are well acquainted with existing models and construction. This means that not only the design must be kept in progress with the times in efficiency and appearance, but that the salesman must be thoroughly schooled in presenting these features in a conclusive manner.

EFFECTS of design on sales are not always recognized readily or generally. However, the more or less obvious fact is: No new design—no sales. On the other hand: No sales—no new design; abundant proof that perfect co-ordination between the two is essential. Mr. Rauch touches on this in the accompanying article, written from the viewpoint of a chief engineer. Subsequent contributions will treat other phases of this timely subject.

More than ever design and sales of any product, whether it be mobile or immobile, must go hand in hand if the product is to be kept up to or ahead of the expectations of the buying public and the volume of sales maintained. In the absence of a research department, the engineers or designers are in fact dependent to a great extent on the sales department for furnishing the data necessary to determine advance demands in design. Therefore, a keen analytical sales department can be of immeasurable assistance to the designing department. This would create an ideal situation, but unfortunately it is not always possible from a financial or manufacturing standpoint to make major changes, and in many cases minor changes, in the design of a product already in production even though all concerned are agreed that it would be in line of an improvement.

As an example of this, when the gasoline pump first was placed on the market following the advent of the automobile, a prominent concern had practically a monopoly on the business. The design of their pump, however, was unattractive and a competitor realizing the situation brought out a pump of more pleasing design. With a much smaller sales force he was able to take the business away from the originator. The original manufacturer found himself in the position of being unable to change his design owing to the great cost involved in jigs, fixtures and manufacturing equipment for the one particular model until it was too late.

Appearance in the design of a piece of machinery counts for much today. It must be graceful, efficient, yet in most cases conveying the idea of sturdiness and ruggedness, as well as being convenient and quiet in operation.

Radical departures in design are not accepted readily even though they are decided improvements because the trend of thought of the designer is running years ahead of the time the public is ready to receive it. This is attested to in the patent situation. Many patents that were taken out ten years ago just now are being utilized and realized on. The same is true of the patents issued today, many of which will not be utilized for years to come.

The problem for the designer, therefore, is to concentrate on a design for which there is a constant demand due to its unique features or performance and at the same time be within a reasonable cost of production. The Ford car is a good example of this. Any number of products might be designed for which there would be no market, but on the other hand there are many articles yet to be designed for which there is a ready sale.

Several years ago a shipbuilding company was in the market for a number of large tanks to be built in accordance with their specifications. These specifications were such that a certain manufacturer could not come within a competitive price owing to the nature of his shop equipment, but the sales engineer who represented the manufacturer, by suggesting certain changes in design not affecting the general appearance, utility or strength of the tanks, was able to secure this large order.

Many such cases might no doubt be recalled where design and sales both contributed toward securing business by working together. The sales viewpoint always must be kept in mind by the designer in order that he may be the better able to meet the demand.

Meeting High Pressure Problems in Journal Bearings

Design of Bearings Carrying High Intensities of Pressure, Changes with the Progress Made in Fluid-Film Lubrication

BEARING design problems created by demands of modern practice provide the substance of a paper presented by A. G. M. Michell, Michell Crankless Engine Corp., New York, at a recent meeting of the American Society of Mechanical Engineers. These intricacies in film-lubricated bearings, particularly of the pivoted journal type are discussed.

TO the machine designer all bearings are of course necessary evils, contributing nothing to the product or function of the machine; and any virtues they can have are only of a negative order. Their merits consist in absorbing as little power as possible, wearing out as slowly as possible, occupying as little space as possible, and costing as little as possible.

A bearing obviously is apt to meet the last two of these desiderata in proportion as its bearing surface is diminished; or, since the load to be carried is nearly a predetermined quantity, in proportion as the intensity of pressure on the bearing surface is increased.

It fortunately appears, according to the hydrodynamical theory, that the power lost in friction also diminishes as the intensity of pressure is increased. At the same time, provided due regard is had to the conditions, there need be no diminution of the bearing's fourth possible negative virtue, namely, absence of wear.

Roundly speaking, therefore, progress in bearing construction consists in finding safe methods of increasing the intensity of bearing pressures. In order to do so we not only must form the bearing surfaces suitably, as the hydrodynamic theory instructs us to do, but also must provide for the supply of the lubricant which the theory postulates, and for the abstraction of whatever heat unavoidably is generated.

How far existing journal bearings fall short of the ideal of negligible size and cost may be appreciated from Fig. 1. This shows a typical large turbo-alternator with its journal bearings, one of which is incorporated in a common casing with the adjacent journal bearing of the turbine and with the coupling connecting the two shafts. The diameter of the shaft is 21 inches.

The set of three bearings and the coupling occupy a total length of 18 feet, as compared with 14 feet which is the length of the useful part of the alternator between its bearings. That manifest disproportion has been brought about because the designer, working on conventional lines, has not been prepared to load the bearings to more than about 60 pounds per square inch of the projected area of the journal surface. Still lower intensities of pressures, about 25 pounds per square inch of projected surface only, have continued to be the rule for many years in another important class of large journal bearings, namely, marine propeller-shaft bearings. Such cylindrical-shell bearings have indeed made little or no progress toward

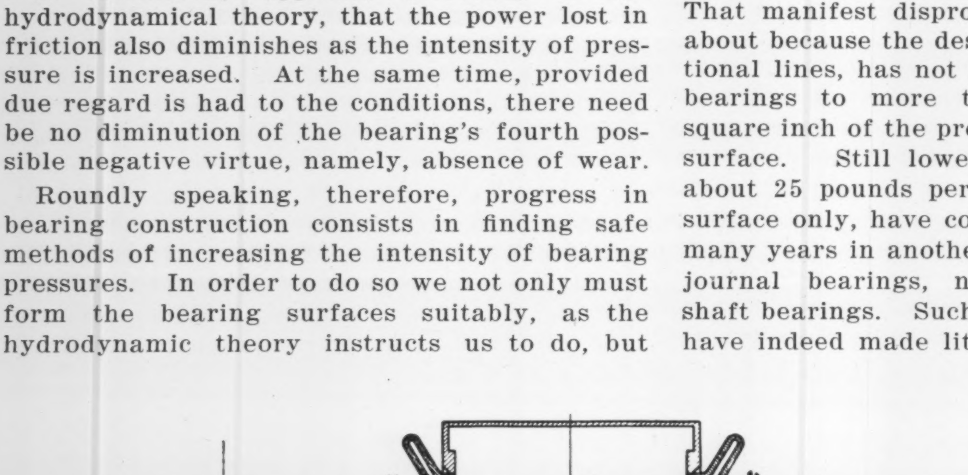


Fig. 1 — Journal bearing arrangement of typical large turbo-generator. Total length is 18 feet as compared with 14 feet, the length of the useful part between bearings

meeting the desiderata before mentioned since the beginning of this century.

In both the plane and the cylindrical bearing the essential feature is the existence of the two bearing surfaces—one continuous in the direction of motion, the other discontinuous—sliding with respect to one another and to the interposed film of lubricant. In both cases it is essential that the film shall be of varying thickness, and of generally diminishing thickness in the direction of motion.

Lubrication Film Is Wedge-Shaped

Fig. 2 shows, juxtaposed, two views of a plane and a semicylindrical bearing, each with a more or less wedge-shaped film. In each case the surface *AB* is the continuous, and *CD* the discontinuous surface. Reference will be made again later in a different connection to continuous and discontinuous surfaces.

The most significant difference between the cylindrical bearing and the plane bearing is that while in the plane bearing the convergence of the wedge film necessarily is uniform throughout its extent, in the cylindrical bearing the same film may be converging and diverging at different points. Thus in the cylindrical bearing shown in Fig. 2, the interspace diverges from *C* to *E* and then converges from *E* to *D*. In the plane bearing, moreover, the surfaces necessarily come into contact over the whole of their common extent when the thickness of the wedge film is diminished to zero. In other words, both surfaces have the same, in this case, zero, curvature. In the cylindrical bearing the curvatures may differ, so that contact between the surfaces, the film being removed, is upon a line only. To attain success the characters of the journal bearing should be assimilated to those of the successful thrust bearing. If this view is adopted unreservedly, three maxims may be stated for the construction of successful film-lubricated journal bearings. These are:

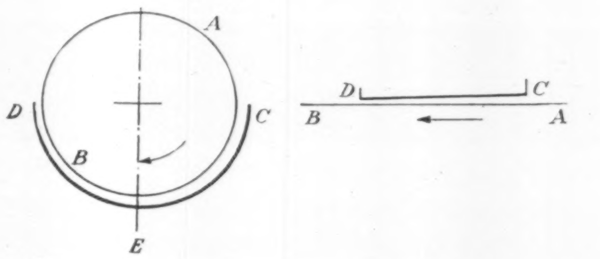


Fig. 2—Diagram of semicylindrical and plane bearings, each with wedge-shaped film

1. The wedge film should be wholly converging in the direction of motion of the surface, that is, the journal.
2. The two surfaces should have the same curvature.
3. The discontinuous element must be pivoted, this being the only known method of producing with certainty the proper convergence of the wedge film. Space available will permit only a brief and incomplete justification of these axioms.

Nonrecognition of the first, that is, continuous convergence, has been apparently due to the fact that mathematical solutions hitherto given, cover only the imaginary case of a bearing of infinite width in the direction of the axis. It has been demonstrated that in such infinite bearings even diverging sections of the oil film can contribute to the generation of pressure provided that they are followed by strongly converging sections. It is easy, however, to see that the bearing of limited width is in a quite different condition from the infinite bearing, with respect to the effects of divergence.

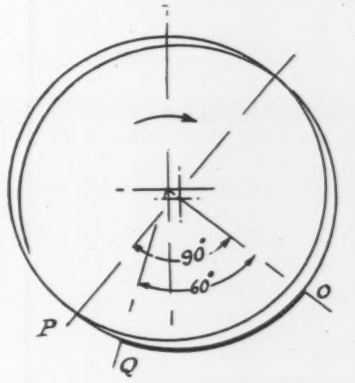


Fig. 3 — Equal circles of curvature of fitted journal and bearing. Arcs of 45 degrees seem to be the most advantageous

Make Curvature of Bearing Surfaces Equal

The second axiom, namely that the curvature of the two surfaces should be equal, the bearing being thus what has been called a "fitted" bearing, rests mainly upon practical considerations. One of these is that to make the bearing element of equal curvature with the journal is the only generally practicable method of making its surface in any sufficiently accurate relationship thereto. The relation of equality easily is made and checked in the first instance, and easily restored by any competent mechanic. The most serious defect, however, of the bearing in which the step is of greater radius than the journal, is that the effective area of the fluid film diminishes rapidly as the load on the bearing is increased, so that the miximum intensity of fluid pressure increases much more rapidly than the load. Although extremely thin films may be stable, as shown, for instance, by Stanton, the coefficients of friction in such cases are apt to be much lighter than in films of normal thickness, and the danger of seizing is imminent.

Axioms 1 and 2 together, if accepted, impose further conditions on features of the bearing. It is obvious by inspection of Fig. 3 which shows the equal circles of curvatures of a fitted journal and bearing, that the maximum possible arc subtended by the bearing without divergence is 90 degrees, from *O* to *P*, and in that case the film thickness is zero at the trailing end and the rate of convergence is zero at the leading end. With an arc of 60 degrees, the ratio of film thickness at leading and trailing edges may be the standard 2 to 1, but if so there is still only a zero rate of convergence at the leading edge. The axioms stated therefore imply the use of bearing arcs of less than 60 degrees. Arcs of approximately 45 degrees appear to be the most advantageous on the whole. Fig. 4 illustrates a simple example of the pivot arc construction, in which it will be seen that 6 pivoted bearing elements, each subtending about 45 degrees, are arranged around the circumference so that in whatever direction the journal is loaded it is efficiently supported by at least two of the elements, which are free to turn upon their pivots so as to present their working surfaces in correct relation to the journal. This advantage of the pivoted element accrues of course over and above its fundamental function, namely, the automatic determination of the desired distribution of load over each single element. Pivoting secures the still further advantage that overstressing of the element by local contact with the journal is wholly excluded, even up to the edges.

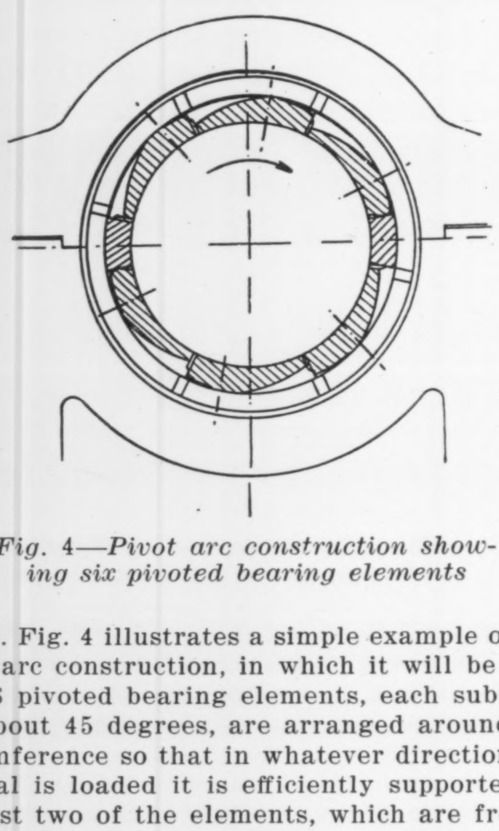


Fig. 4—Pivot arc construction showing six pivoted bearing elements

Calculation Shows Safe Figures

It sometimes is objected that the proposed higher intensities of pressure in pivoted segment bearings involve reduction of the film thickness to the point of danger. Calculation shows, however, that even with oils of the low viscosities advocated for use in these bearings, the minimum film thickness of the alternator bearing above illustrated is 1.4 thousandths of an inch (0.0014-inch), which certainly is a safe figure for pads whose bearing surface is only about 10 inches square. The low mean intensity in the conventional bearing indeed defeats its own object, since the necessary journal becomes so long and flexible, and the long shell so subject to deformation, that the concentration of pressure at the ends, or some intermediate point, is virtually certain. The oil film is reduced at such points to a thickness far less than the minimum in a well-designed pivoted bearing.

Another objection that may be raised is that the increased intensity of pressure, even though it results in a lesser total production of heat as the theory indicates, involves a greater intensity of generation of heat per unit area of surface and hence higher working temperature. The objection contains a fallacy inasmuch as the oil acts as a conductor of the heat generated.

Theory Discloses Temperature Rating

The theory shows that, other conditions being constant, the heat generated varies directly as the square root of the intensity of pressure. The oil film, however, varies in thickness inversely as the same square root, and consequently its conductive power increases *pari passu* with the heat generated and the temperature difference is unchanged by increase of the intensity of pressure. The formula, in fact, for the excess of temperature at the middle plane of a film of thickness $2h$, between the surfaces moving at the relative velocity V, is simply $T = \mu V^2/C$, involving neither the load nor the film thickness.

It is assumed of course that the necessary provision is made for dissipation of heat from the bearing as a whole, either by cooling the circulated oil externally or otherwise.

The question often is raised: What is the special characteristic of the fluids classed as "oils," by virtue of which they are used almost exclusively as lubricants in machine bearings? No quite satisfactory answer appears to have been given, or at least there is no agreement as to what is the true answer. One factor is evidently the surface-tension characteristic, especially relatively to metals, by reason of which oils insert themselves into every narrow interspace between a pair of surfaces of metal, and thus provide the first condition essential for the formation of a lubricating film, namely, that the lubricant shall be present.

There appears to be an impression that by reason of their containing plastic solid constituents, greases necessarily form thicker lubricating films than liquid lubricants. This idea seems to be derived from the general experience that greases are safer lubricants than oils where only rough fitting of the bearing parts can be attained, or where grit unavoidably is present. The idea nevertheless is erroneous.

Preserving Valuable Drawings

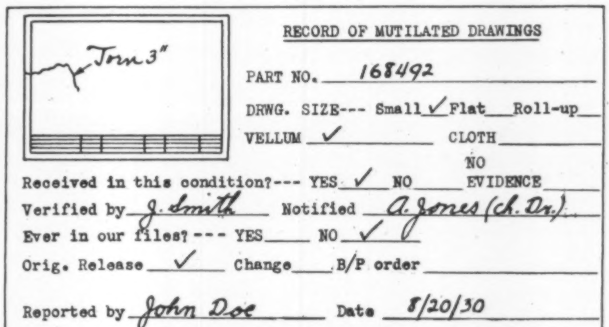
By E. L. Chevraux

THIS article is the first of two prepared by E. L. Chevraux who at present is supervising the engineering record division of the Studebaker Corp., and is the originator of much of the systematic procedure in that organization. Primarily he takes the viewpoint of procedure in a big organization but all of his suggestions are applicable also, in some degree, to smaller companies.

ORGANIZATION of many departments for the recording and filing of engineering drawings seems to have been established along purely traditional lines. Competition in industry has brought constant changes and refinements in design, but in many organizations the methods of handling valuable drawings have not kept pace with the march of progress. On the other hand there is evidence that quite a number of large present-day corporations have grown from the early stages when only one $5.00 a week boy sufficed for doing all the filing, in addition to the making of blueprints in a sun-exposure frame.

True, necessity has put the latter in the scrap heap and substituted one or more modern, continuous blueprint machines. Consequently, personnel has been increased in numbers—but the sad commentary is that, in too many instances, the "caliber" of the help has remained practically the same, including even those intrusted with direct supervision of this work.

Not the least of this chain of antiquated procedure is the fact that "new" filing cabinets still are being ordered in perpetuation of the idea that they must intermember with or match those of the original design. In some cases concession is made to the point that steel cabinets are purchased in place of wooden ones, because of the former being more fire-retardment. But there is still the persistent idea that the design otherwise shall remain identical with those first used. This latter phase is one of the biggest problems in the handling and preservation of costly drawings and will be covered in a subsequent article in detail, with suitable illustrations.



Torn 3"

RECORD OF MUTILATED DRAWINGS

PART NO. 168492

DRWG. SIZE--- Small ✓ Flat __ Roll-up __

VELLUM ✓ CLOTH __

Received in this condition?--- YES ✓ NO __ NO EVIDENCE __

Verified by J. Smith Notified A. Jones (Ch. Dr.)

Ever in our files? --- YES __ NO ✓

Orig. Release ✓ Change __ B/P order __

Reported by John Doe Date 8/20/30

Additional Remarks on Reverse Side

Fig. 1—Sample of form which is employed for reporting conditions of drawings

Observations while making surveys in many organizations have led to the conviction that in a number of instances the management and a goodly number of engineers and draftsmen are over-inclined to think of this division of work as still belonging to a "kids" department. This erroneous feeling is conducive to the hiring of so-called "cheap" help, resulting in careless handling of drawings with consequent tearing and cracking. This mutilation means lost time and errors in reading poor blueprints and eventually entails the prohibitive cost of retracements. Experience is responsible for the firm opinion that if boys are to form the major portion of the personnel of such an organization, they always should be hired with a view to potential possibilities, not solely on qualifications for the immediate position only.

Promotion Prospect Is Incentive

In this connection, may I not submit for the reader's consideration the thought that an organization cannot attract nor hold the best type of personnel unless a reasonable prospect of promotion is offered. This applies equally well to those other than the younger element. As individuals, an organization may be a well co-ordinated machine, but there always is the necessity for continuous executive attention to keep it oiled and running smoothly. Therefore it is well to exercise great care in the appointment of leaders who can handle the personnel of an organization and also be capable to taking the initiative in devising better systems while keeping an eye open on the matter of cost reductions.

Summing up this portion of the subject, it is the writer's personal opinion that the daily handling of thousands of dollars worth of drawings certainly warrants an expenditure of money in wages sufficient to secure the best of help.

Preventing Torn or Damaged Drawings

Frequent references made to drawings necessitates their removal and replacement in file, with ultimate result that they soon show unmistakable signs of wear and tear. Transmission to and from the blueprinting department and during the work of reproduction also has a tendency to produce the same conditions. This is an experience common to practically all drafting rooms and to a large extent is unavoidable.

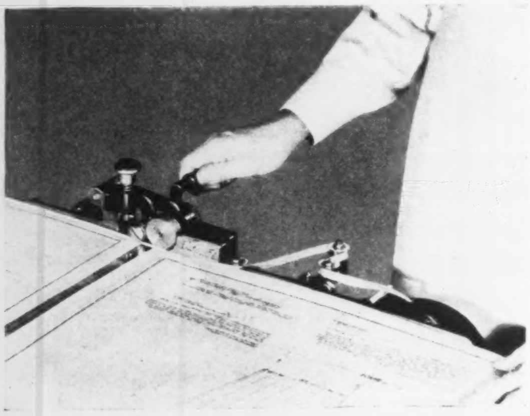


Fig. 2—New machine for applying edges on drawings to prevent tearing

With these thoughts in mind the writer introduced a form as shown in Fig. 1, which was designed for reporting periodically the true status of the question regarding mutilated drawings. It not only gives an accurate accounting of this condition, but its employment has a psychological effect on the minds of those prone to fall back into carelessness in this one respect at certain intervals. Knowing that practically every mutilation, no matter how slight, is to be recorded against him, naturally makes one more careful with drawings entrusted to his care.

Certain large organizations make all drawing reference through the medium of getting the tracing out of file, under the plea that the need for absolute accuracy prohibited using blueprint files. Almost constant use of original drawings in this manner is conducive to short life. Insurance that a blueprint file always is up-to-date may require intelligent care and extra help, but in most cases the consequent increase in blueprint cost is more than offset by the saving in mutilated tracings.

Another practice, which is followed in many organizations, is to make changes on tracings and then pass them through multiple hands for the perusal of those executives whose duties are to determine the advisability of making the changes in question. Even if the changes as made finally are approved this procedure is acting to decrease the life of drawings through unnecessary and excessive handling. In case proper sanction is not given the changes, it becomes necessary to make erasures etc. to restore the drawings to their original state, thereby lending further effort against the problem of preservation. In practically every instance the whole matter could be covered better and made more quickly understandable if marked-up blueprints were utilized—augmented, of course, with a descriptively worded "Change Request" form for the signature and comments of those in authority. Likewise, much of the work in the record department could be done through reference to blueprints, allowing the tracings to move to the files soon after issuance.

By far the majority of mutilated drawings start with tearing of the edges. The tendency among file clerks often is to neglect repairing these tears until they eventually are lengthened to a point where they reach into the drawing proper. Subsequent attempts to make necessary repairs with adhesive tape result frequently in almost undecipherable blueprints.

Machine Applies Edging Paper

Recently a new machine was placed on the market for applying an "edge" on drawings which prevents tearing. This method can be utilized on absolutely new drawings, solely as a preventive measure or in mending the edges. The trade name of the machine is "Prakma." Reference to Fig. 2 will give the reader some information regarding the operation of the machine and results obtained. As it is run through the machine, by the turning of a crank, a special edging paper coated with an adhesive is folded automatically over the edge of a drawing, forming a marginal band approximately 3/16-inch wide on both front and back sides of the drawing. Simultaneously, a double-strength linen thread is fed inside the tape and lies at the fold in the paper against the extreme edge of the drawing. An electric heating element prepares the adhesive coating so that it will stick on any material, including prepared tracing papers, vellums, tracing cloth, etc. This edging has a tendency to make tracings lie flat and allows for an increased number of drawings in a given filing space.

Machines of this type quickly attached to any table by means of winged thumb screws, now are being installed in many commercial blueprint and drafting material supply houses to do the work for those small concerns whose requirements would not warrant the purchase of such equipment. The invention has all the appearances of furnishing a practical means of protecting valuable drawings against destruction.

PROFESSIONAL VIEWPOINTS

Publication of letters does not necessarily imply that MACHINE DESIGN *supports the views expressed*

Comments from Our Readers. Machine Design Will Pay for Letters Suitable for Publication

Itemized Index Is Useful

To the Editor:

I HAVE noted with much interest the addition of an itemized index in the August issue of MACHINE DESIGN. This feature is particularly helpful, especially in view of the fact there are included in this index advertisements as well as editorial items.

It is the writer's opinion that, if the advertiser in such a publication as MACHINE DESIGN prepares his copy so as to appeal to the designer with the idea of showing how the product can help solve his designing problems, the advertising pages are of as much interest and value as the editorial pages.

The index already has proved useful to me and I anticipate making constant reference to it.

—L. R. TUFTS,
Cleveland

Employs Graduated Curves

To the Editor:

MOST engineers when designing some particular part of a machine involving an irregular curve, do so by fairing in the curve with some part of a standard irregular curve and often a series of curves; but rarely do they convey this information to the patternmaker or the mechanic in the shop who is to reproduce the curve. The result is that the mechanic must consult the designer, who by this time cannot readily reproduce the exact curve without going through the same procedure he did originally.

Such a waste of time may be overcome by marking off standard irregular curves in graduations as shown by the accompanying sketch. Thus, when the occasion arises, the designer can make note on his drawing that the curve shown was faired in by the number of the curve giving the graduations between points. For example "curve No. 15 from 4 to 8.2" indicating the curve is from point 4 to two tenths past point 8. The curves should be graduated on both faces for the purpose of reversal or for reproducing the same curve on each side of a center line.

—HERBERT STERLING,
Philadelphia

Choosing the Right Material

To the Editor:

UNTIL fairly recently the engineer and designer could with reasonable assurance base his choice of materials in design on any good text book dealing with the subject. Selection was made along broad fundamental lines, and compared with modern day opportunities the range of choice was rather restricted.

With the advent of the many current special and highly technical materials, with their possibilities of refinement and ramifications of properties, the text book basis has been relegated to a more passive role, and up-to-date engineers have learned to depend more on current technical advertising, magazine articles, manufacturer's literature and sales representatives. The manufacturers of raw materials have done their part to modernize the distribution of technical information, even going so far as to reorganize their sales forces in terms of sales engineers rather than the old fashioned

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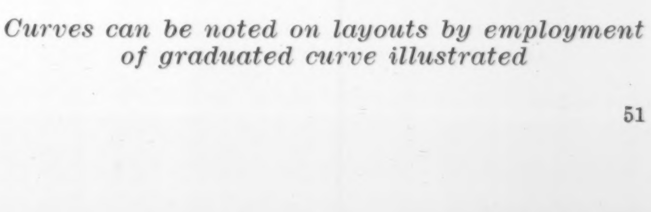


Curves can be noted on layouts by employment of graduated curve illustrated

MACHINE DESIGN

Editorial

An Acknowledgment

ON THIS the first anniversary of MACHINE DESIGN, I wish to acknowledge my indebtedness to all individuals and organizations whose encouragement and co-operation have been invaluable in making this publication a success:

To those men who foresaw clearly the need for a medium to serve designing engineers and whose suggestions assisted largely in its fulfillment.

To the officers of Penton Publishing Co. who, once they were convinced of the need through their own thorough investigation, placed behind MACHINE DESIGN their financial and editorial resources and gave to it the advantages of their years of experience in the technical publishing field.

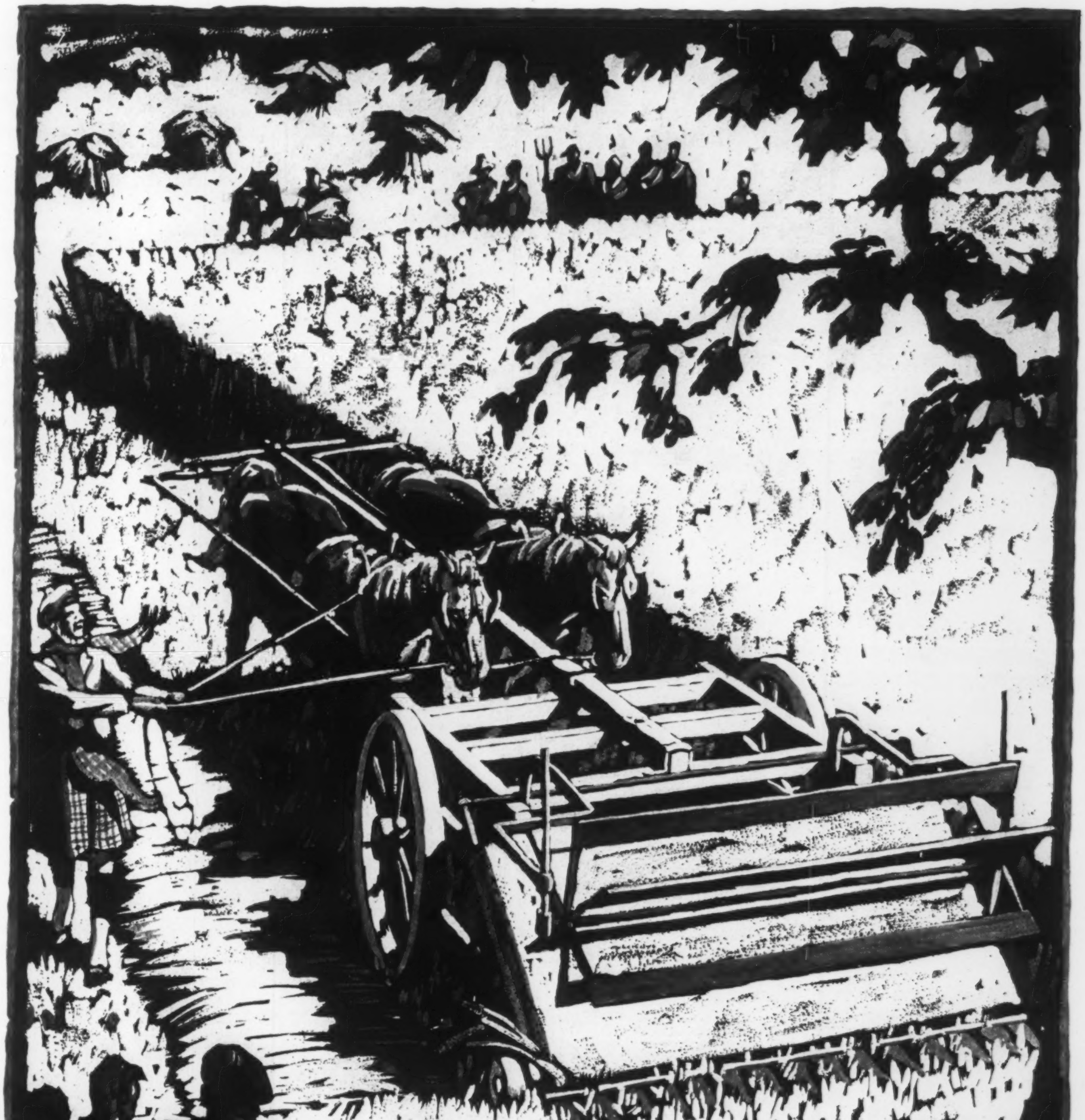
To those companies and their advertising agencies whose faith in the idea back of MACHINE DESIGN and whose confidence in the ability of this organization to accomplish its purpose contributed so greatly to the present position of the journal.

To the editors and contributors who have made the publication interesting and valuable to thousands of engineers responsible for design of all types of machinery. Their work is the firm foundation upon which this magazine is built.

To those executives and engineers who have so definitely placed their stamp of approval on MACHINE DESIGN by voluntarily becoming regular and commendatory subscribers.

Franklin H. Johnson

Publisher.



Patrick Bell and the Reaper

Great Moments in Machine Design—Thirteenth of a series of original drawings prepared exclusively for this magazine symbolizing the designer's contributions to the progress of mankind

NOTEWORTHY PATENTS

A Monthly Digest of Recently Patented Machines, Parts and Materials Pertaining to Design

VARIABLE speed motors and transmissions are playing an important role in industry and new equipment of this type is commanding unusual interest. Novel in design is the unit recently patented by Richard S. Jacobsen, Wheaton, Ill., and assigned to the J. F. S. Co., Chicago. The patent number is 1,770,408. Primarily it involves friction drive gearing employing rolling elements to change the speeds.

The illustrations below show Fig. 1, longitudinal section; Fig. 2, one of the rolling elements; and Fig. 3, a transverse section on line 2—2 of Fig. 1. Shaft 5 is driven by any suitable power and the pinion 11 is fixed to it to engage the gears 9, so that rotation of the shaft will revolve sleeve 7 in the same direction but at a different speed. Coil springs 16 and 17 press the two raceways 12 and 13 toward each other. Driven shaft 18 is aligned with shaft 5. Casing 1 is provided with raceway 23 and the member 22 has a similar raceway 24. Screw 25 inserted through casing 1 engages groove 26 in member 22 to hold 22 against rotation, but allowing it to slide axially. For this adjustment a handwheel 27 is provided.

There are three rolling elements 30 mounted on axes carried by arms 31. When the shaft 5 is rotated the consequent rotation of sleeve 7 will revolve the raceways 12 and 13, causing the members 30 to roll around on the raceways 23 and 24. Shaft 5 is the power input member while 18 is the power output shaft and transmits the power from the mechanism at the desired speed.

When the raceway 24 is moved toward the raceway 23, the raceways 12 and 13 thereby are crowded farther apart, so that these two inner raceways then engage the rolling members at or near their outer ends. Because of the smaller diameter of these rolling members the output shaft 18 is cause to rotate faster. Vice versa the speed of shaft 18 is reduced as the raceway 24 is moved away from 23. Handwheel 27 affords manual control of the speed to be attained.

Since the members 30 are tapered toward their opposite ends, in the manner shown, in Fig. 2, with some inward curvature, it will be seen that their surfaces engage the raceways in such a manner as to roll with very little, if any, grinding action on the raceways. This condition persists regardless of where the raceways engage the rotary elements 30, and regardless of whether the mechanism is working with high speed or low speed transmission.

TO eliminate substantially the side pressure of pistons against cylinder walls, Joseph L. Boland, Keyport, N. J., has invented an internal combustion engine in which the piston rollers are interconnected in series with a set of intermediate rollers. The patent, No. 1,765,713, which recently was awarded for the invention, has been assigned to Aeromarine Plane & Motor Co. Inc., New York. Fig. 1 shows a cross sec-

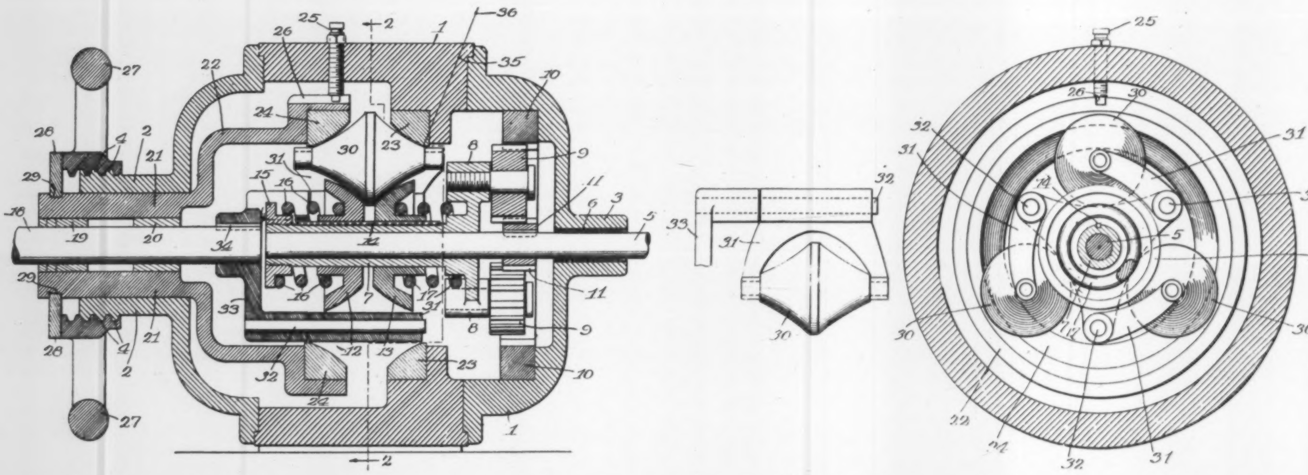


Fig. 1—Longitudinal section of speed change gearing. Fig. 2—Detail view of one of the rolling elements and a portion of its support. Fig. 3—Transverse section on line 2—2 of Fig. 1

tion of the engine and Fig. 2 a longitudinal section taken on the line 2—2 of Fig. 1.

Each piston 19 is provided with a roller 21 rotatably mounted upon the usual wrist pin 22, the rollers being provided with side flanges and adapted to ride on the cam 13. By this arrangement the shaft 11 is driven, and one of the rollers 21 always is disposed in a driving position relative to the cam 13. A pair of cam elements 23 and 24 are mounted on either side of cam 13, identical in peripheral conformation but of a profile somewhat different than the main driving cam 13. A number of double rollers 26, 27 and 28 are mounted in rolling contact with cams 23 and 24 and straddle cam 13.

As shown in Fig. 1 the rollers 26, 27 and 28 are disposed radially between the cylinders and they do not at any time tend to operate the drive shaft 11. Their function is to coact with the cams 23 and 24 to create a force which when transmitted through the linkages, will constrain the piston rollers to follow the outline of cam 13 and thus enforce a constant bearing relation therewith during the operation of the engine.

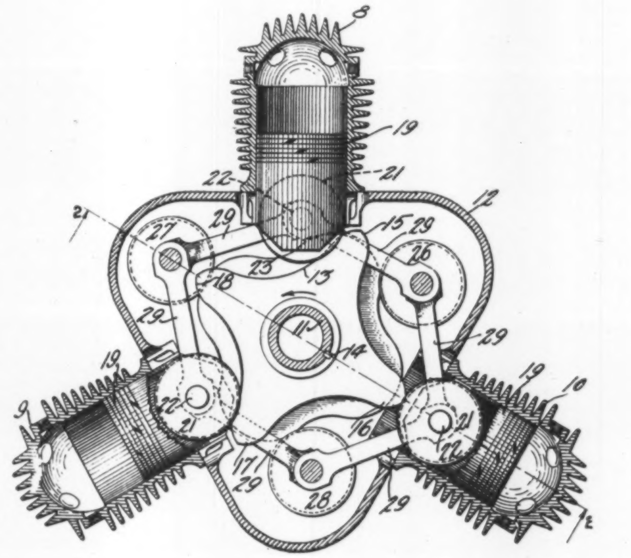


Fig. 1—Cross section of internal combustion engine with portions of pistons broken away

Another important function of this mechanism is the elimination of the usual side pressure. Assuming the engine to be of the two-cycle type, piston 19 of cylinder 9 is on the firing stroke while cylinder 10 is in the act of firing, the piston of cylinder 8 being on the compression stroke. With the roller of cylinder 9 transmitting the piston thrust to the cam lobe 17, there is a component force generated due to the position of the roller on the cam. This force tends toward lateral displacement of the piston, which ordinarily causes side pressures.

With cylinder 8, which is on compression stroke, the cam lobe 15 also is imposing two forces upon the piston, an initial side thrust which is transformed into an axial thrust by the resistance of the cylinder walls. It should be noted that the side thrust of this piston is in a direction opposed to that of cylinder 9. Rollers 26, 27 and 28 being connected by linkages 29, the forces are acting largely in opposite direction which has a tendency to equalize them.

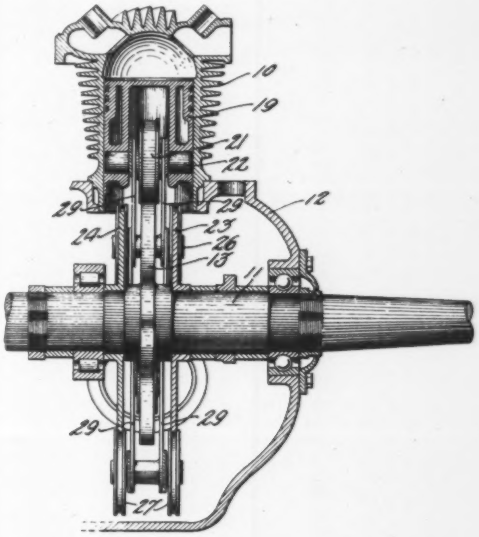


Fig. 2—Longitudinal section of engine taken on line 2—2 of Fig. 1

In view of the fact that all of the rollers are connected in series by the linkages, the tendency of any piston toward side pressure is resisted by all the other pistons within their cylinders.

Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

ROTOR—1,773,739. This patent covers a rotor comprising a core and a die cast zinc base alloy containing aluminum 4, copper 3 per cent and the balance zinc. Assigned to McCollum Hoist & Mfg. Co., Downers Grove, Ill.

ROLLER BEARING—1,772,711. A bearing structure comprises this patent which also includes coverage of lubricating means for the invention. Assigned to Link-Belt Co., Chicago.

DRIVING MECHANISM—1,773,206. A motor vehicle driving mechanism employing clutching means for automatically releasing the wheels to permit coasting. Assigned to William O. Stokes, Good Ground, N. Y.

NONCORROSIBLE BEARING. 1,771,994. "In a bearing construction, the combination with a base member having an attaching wall and an outstanding supporting flange thereon, of a ball race supported on said flange, a cover plate co-operating with said base member to form a lubricant chamber, and a shaft extending through the cover plate only and supported in the ball race, the cover plate being provided with a fastening element contacting with the top of the ball race to maintain it against the flange." Assigned to Photostat Corp., Providence, R. I.

MEN OF MACHINES

Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design

PRESIDENT of the Bristol Co., Waterbury, Conn., at the age of 42, places Howard H. Bristol among the prominent younger executives who have risen from engineering ranks. His recent election to this post makes him head of the firm founded by his father and uncle. Mr. Bristol was born Jan. 23, 1888 at Naugatuck, Conn., and was graduated in 1910 with a mechanical engineer's degree from the Stevens Institute of Technology. Immediately after graduation he entered the employ of the Bristol Co., devoting his entire time to research and development work. In 1912 he organized the engineering department and was appointed chief engineer. He occupied that position until 1920, when he was elected vice president and assistant treasurer as well as director and general manager. When the president, William H. Bristol, his uncle, died he was named successor.

◆

RECEIVING his education in Russia and called to the Polytechnic Institute of Kiev to occupy the chair of applied mechanics, Dr. S. Timoshenko has become one of the foremost present day engineers. For five years he was professor of applied mechanics in various engineering schools of St. Petersburg and at the Polytechnic Institute in Zagreb, Jugoslavia. In 1923 he entered the Westinghouse research laboratories, leaving there in 1927 to become professor of mechanical engineering at the University of Michigan. In addition to his duties at the university he is consulting engineer and member of the Westinghouse research advisory board. Dr. Timoshenko presented a technical paper at the third International Congress for Applied Mechanics which was held recently at Stockholm.

◆

APPOINTMENT of Joseph W. Barker as dean of the school of engineering at Columbia university, New York, marked the retirement of Dean George B. Pegram after 13 years of service to engage in research. Graduated from the Massachusetts Institute of Technology in 1916, Dean Barker in 1925 received the master of science degree from the same institution. He saw service during the World war, rising to the rank of major prior to leaving the army in 1925. His work during the war brought him in contact with design of machinery of a confidential nature. For a time he was associate professor of electrical engineering at Massachusetts Institute of Technology and a year ago assumed the administration of the department of electrical engineering at Lehigh university. He was made dean at Columbia university July 1, this year.

◆

IN recognition of his scientific and practical achievements in hydraulics, William Monroe White recently was made the recipient of an honorary degree of doctor of science by his alma mater, Tulane university, New Orleans. He was graduated in 1899 and two years later joined the I. P. Morris Co., Philadelphia, as a designer of centrifugal pumps, becoming hydraulic engineer in 1903. During this year Mr. White designed his first large turbine, and since that time has held the record of designing some of the largest units in the world. In 1911 he accepted the position as manager and chief engineer of the hydraulic department of Allis-Chalmers Mfg. Co., Milwaukee, which position he now holds. He has taken out nearly fifty patents covering his inventions, among which is the hydraucone regainer, probably his greatest contribution.

◆

ONE of the three engineers to officially represent the United States at the third International Congress for Applied Mechanics at Stockholm recently was John M. Lessells. He is in charge of the mechanics division of the Westinghouse research laboratories and received his education in Scotland. Before joining Westinghouse in 1920 he was employed by Armstrong Whitworth & Co., the British war office and Rolls-Royce in England. Mr. Lessells is a prominent member of the American Society of Mechanical Engineers and is co-author with Dr. Timoshenko on *Applied Elasticity*.

◆

THIRTY years in the motor truck industry is the record of B. A. Gramm, president and treasurer of Gramm Motors Inc., Delphos, O. The recent celebration of the occasion reflected many interesting details of Mr. Gramm's career as a designer and builder of cars and trucks since 1900. His first experiments were conducted in a small shop in Chillicothe, O., his

Leaders in Design, Engineering and Research

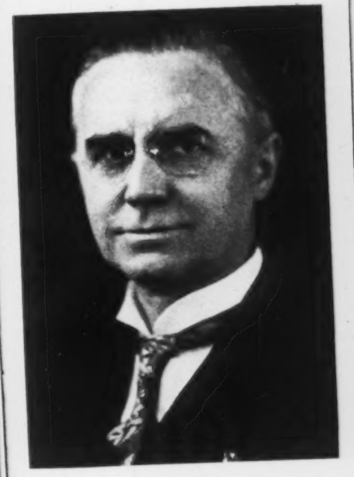
HOWARD H. BRISTOL

DR. S. TIMOSHENKO

JOSEPH W. BARKER

WILLIAM M. WHITE

JOHN M. LESSELLS



B. A. GRAMM

birthplace. In 1904 he moved to the plant of the Logan Construction Co., and produced the Logan, the first two-cylinder truck. In 1906 a four-cylinder truck was built and in 1925 the Gramm industry was reorganized and moved to Delphos. A standardized military truck conceived by Mr. Gramm won the attention of the United States government and during the World war he was summoned to Washington to bring the new idea into production. The Liberty truck was the outcome. On May 28, 1919, Ohio Northern university conferred on Mr. Gramm the degree of master of arts.

* * *

A. R. Maier, formerly assistant chief engineer for the Atlas Imperial Diesel Engine Co., Oakland, Calif., has been placed in charge of design of prime movers and slush pumps with Wilson-Snyder Mfg. Corp., Braddock, Pa.

* * *

G. H. Brandt has resigned his position as engineer with the H. K. Ferguson Co., Cleveland, to become designer for the Electric Controller & Mfg. Co., Cleveland.

* * *

J. H. Van Campen has been appointed chief engineer of both the Youngstown and Warren districts of Republic Steel Corp., Youngstown, O.

* * *

C. H. Dengler, formerly chief engineer, New Way Motor Co., Lansing, Mich., now is designing engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

* * *

F. K. Knohl, formerly truck designer, Fargo Motors division, Chrysler Motor Co., Highland Park, Mich., now is research engineer, Illinois Tool Works, Chicago.

* * *

Vance Breese now is assisting with designing, sales and test work with the Detroit Aircraft Co., of Detroit. Until lately he was president of the Breese Aircraft Corp., of Portland, Ore.

* * *

Lynn Reynolds, formerly chief engineer of the Apache Motor Corp., Van Nuys, Calif., recently was made resident engineer for Continental Construction Corp., Kansas City, Mo.

* * *

A. R. Smith has been appointed executive engineer of the turbine engineering department of the General Electric Co., Schenectady, N. Y., to succeed the late William J. Delles. Mr. Smith will retain his responsibility as engineer of the construction engineering department. He has been with the General Electric company since 1897, and with the construction engineering department since 1908.

* * *

John Chucan has resigned as chief engineer, Mercury Mfg. Co., Chicago, and is traveling in Europe.

* * *

G. C. R. Kuiper, formerly chassis experimental engineer, Stutz Motor Car Co., Indianapolis, now is assistant to the chief engineer, Midland Steel Products Co., Cleveland.

* * *

A. G. Plimmer, formerly machine designer, National Carbon Co., Fremont, O., now is foreman in charge of the experimental department, Cincinnati Grinders Co. Inc., Cincinnati.

* * *

William Everson, inventor of the Everson furrow broadcast seeder, has resigned as secretary-treasurer of the Giddings Mfg. Co., Fort Collins, Colo., to devote all his time to the sale of Everson seeders.

* * *

J. B. Jackson, recently director of the general staff and director of the research laboratories of General Motors Corp., has been made general manager of the Jaxon Steel Products Co., division of General Motors.

* * *

Lewis H. Reid has been appointed chief engineer, in charge of research and development, of the Magnetic Analysis Corp., Long Island City, N. Y. He formerly was chief metallurgist for the American Cirius Engine Co., Marysville, Mich.

* * *

M. L. Carr, formerly identified with Barrington Associates, New York, has been made staff engineer with Pittsburgh Testing Laboratory, Pittsburgh. In his new capacity he will act as engineering consultant and co-operate with the company's clients in purchasing, production and sales problems.

* * *

Everett Chapman has been appointed director of development and research of Lukenweld Inc., division of Lukens Steel Co., Coatesville, Pa. Mr. Chapman will have general direction of laboratory and investigation work in connection with redesigning of machinery parts for the welded steel type of construction. He was graduated from the University of Michigan in

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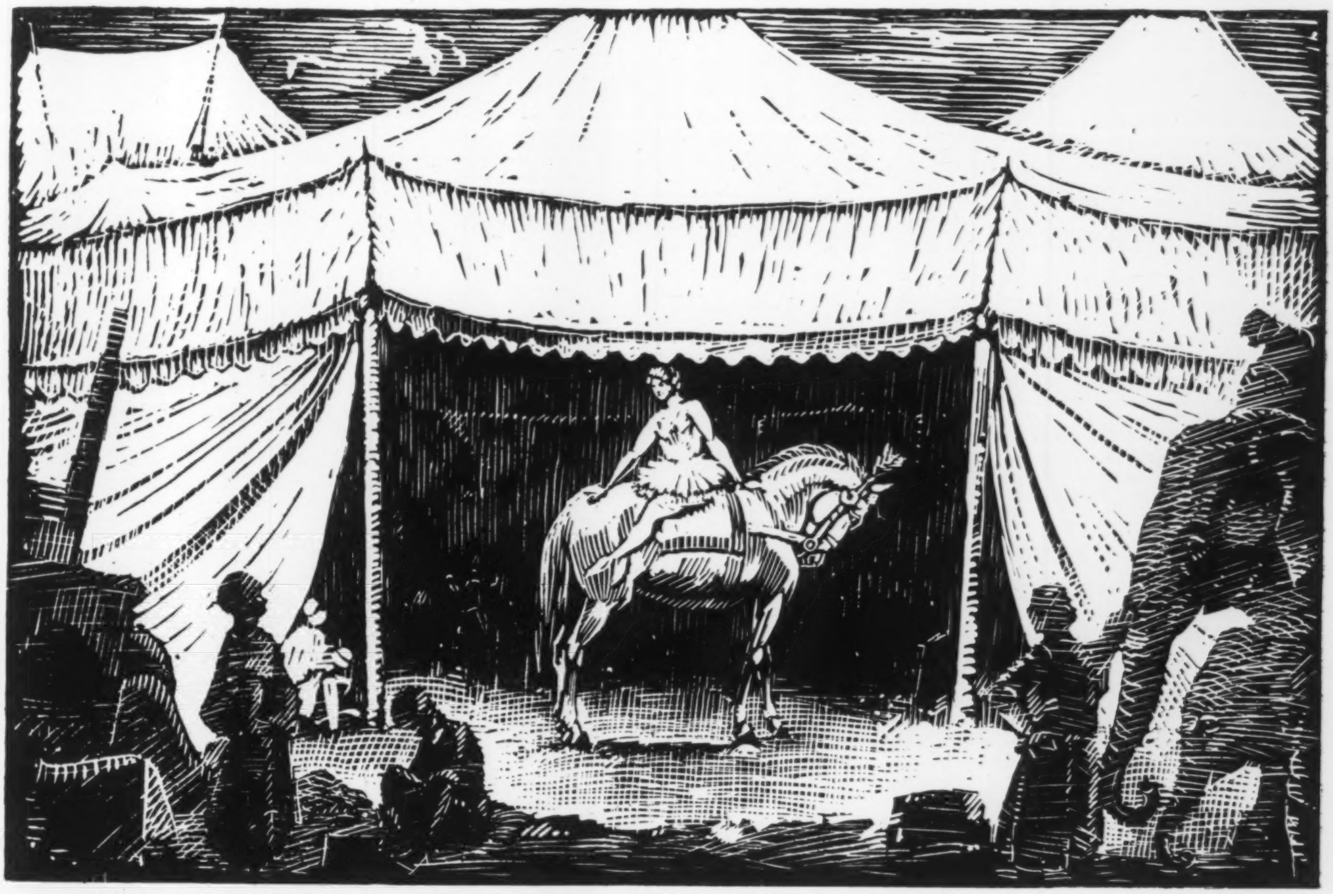


WHEN THE CIRCUS COMES TO TOWN......

The canvas of the "big top" . . . . the wispy skirt of the dainty equestrienne . . . . the long-tailed coat of the dashing ringmaster . . . . the brilliant uniforms of the blaring band . . . . the serge and tweed and silk and fine linen of the wide-eyed audience . . . .

All fabrics are expositions of the art and skill of the textile industry . . . . the products of machines that are marvels of speed and ingenuity . . . . almost human in their automatic efficiency.

And because unusual accuracy, strength and economy are imperative, hundreds of parts of these complicated machines are made from Columbia Cold Finished Steel Bars and Shafting. Columbia Steel and Shafting Co., Pittsburgh, Pa.

COLUMBIA

COLD FINISHED BARS AND SHAFTING

TOPICS OF THE MONTH

A Digest of Recent Happenings of Direct Interest to the Design Profession

As THE much-mooted question of whether the inventions of the engineer belong to his employer comes into prominence again, a news bulletin records the fact that the inventor of a mold wins damages from a large company, his former employer. According to the story the court made the company liable for damages, which it is said may reach $1,000,000, for violation of a fiduciary relation with the inventor of a steel mold for casting locomotive and tender frames in one piece.

It is asserted that the employee was assisted in obtaining his patents by the company attorneys, but was prevailed upon to let the company take them over. Promise of a satisfactory reward is alleged to have been made as soon as the officers were able to estimate the value of the invention. When changes in organization of the company were effected the employee insisted through attorneys that settlement be made, but the officials are said to have stated that "they didn't remember having made any promises to pay the employee for his invention." In handing down its verdict the court ruled that the company was owner of the shop rights in and to the patents, at the same time declaring that the employee was entitled to recover a reasonable value of the patents, or an accounting of earnings less the value of shop rights.

* * *

Tests of Corn Combine Draw Interest in Texas

Movement toward machines designed to accomplish the work formerly requiring several is characterized by the "corn combine," which is undergoing tests in the Texas corn belt. The new machine is called the "gleaner combine" and is attracting considerable interest among farmers in the locality of San Antonio, where the experiments are being conducted. As it moves through the corn field the new machine cuts the stocks off at the ground, shucks, shells and cleans the corn, depositing it in a grain bin on the machine ready for the wagon or sack. The combine is drawn by a tractor and is operated by one man.

Another interesting agricultural engineering event, the world's agricultural tractor trials, is taking place near Oxford, England. These are believed to be the first impartial tractor tests of machines from all over the world and being conducted by Royal Agricultural society in cooperation with the Institute of Agricultural Engineering of the University of Oxford. Tests are being made by one group of experts under comparable conditions. In accuracy and scope the trials parallel those conducted in this country by the University of Nebraska. Reports on the tests will be issued this fall.

* * *

Committee Named To Select Marburg Lecturer

A committee has been appointed by the executive committee of the American Society for Testing Materials to select the next Edgar Marburg lecturer. It is composed of F. E. Richart, research associate professor of theoretical and applied mechanics, University of Illinois; H. C. Mougey, assistant technical director and chief chemist, General Motors Corp.; and T. D. Lynch, consulting metallurgical engineer, Westinghouse Electric & Mfg. Co. Mr. Lynch is chairman.

* * *

Spring Research Bureau Is Formed

Following three preliminary meetings in Toledo, Chicago and New York, representatives of 31 mechanical spring manufacturers met in Toledo, O., recently and organized the Spring Research bureau.

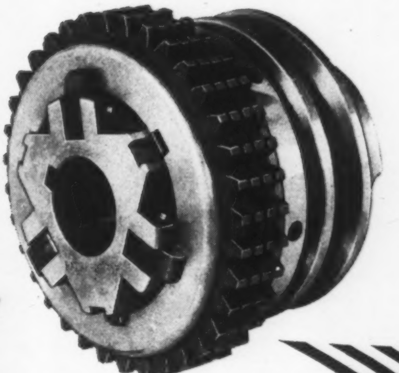
The object of the organization is to establish cordial personal relations between manufacturers of mechanical springs; to promote good will between manufacturers and customers; to study cost accounting and costs of manufacture; to improve and develop commercial methods in manufacturing and marketing springs; to obtain and diffuse information on general trade matters, especially operation and sales and to co-operate with government agencies and departments and other organizations in standardization and association work.

Malcolm Baird, 232 Delaware avenue, Buffalo, is acting as secretary of the organization.

* * *

Design Is a Feature of Aeronautic Meeting

One of the major characteristics of design which has been given serious consideration by all designing engineers has been the tendency of a given airplane to go into a spin. Many engi-



Single "CC" type Twin Disc Clutch, with compressed asbestos, gear tooth driving plates used when clutch runs dry.

...EASY CONTROL

STARTING AND STOPPING IS ALMOST INSTANTANEOUS

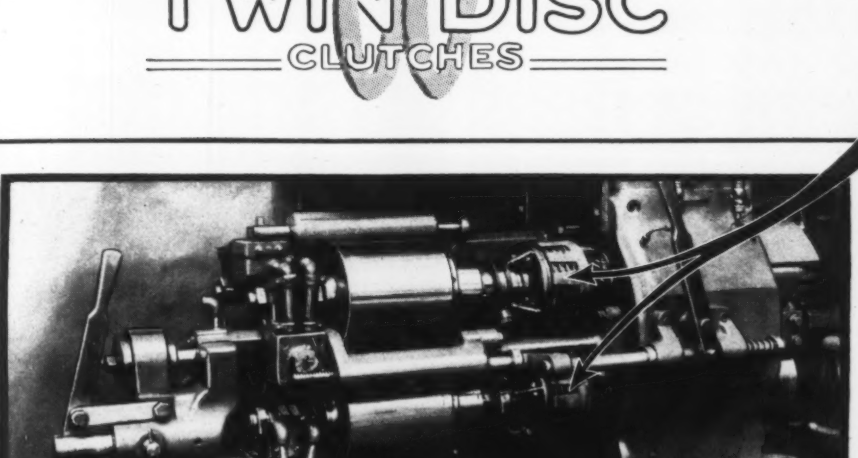
RAPID roughing and accurate finishing of castings, forgings, stampings, bar stocks, etc. is the job of the Model "H" Gridley Four Spindle Automatic Chucking Machine . . . and it has been designed "from the ground floor up" to do it.

Spindle control . . . the National Acme Company's designers decided . . . could be handled best by a Twin Disc, dry plate type, Machine Tool Clutch. No chance for sticking . . . and one or two spindles can be stopped instantly in any of four positions.

More and more machine designers are solving the control problem with the Twin Disc Machine Tool Clutch. It combines capacity with compactness . . . smoothness of performance with greater adaptability . . . and it meets modern methods of design with sizes and types for practically all machine tool requirements. 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7 and 9 inches effective diameters; single or duplex; oil or dry plate.

Write for Engineering Data Book. Specific recommendations gladly furnished by our Engineering Research Dep't. on request. *Twin Disc Clutch Company, Racine, Wisconsin.*

TWIN DISC
CLUTCHES



neers have contended that an airplane which spins easily is difficult to get out of a spin and vice versa. The importance of airplane spinning characteristics and control were discussed pro and con in a symposium at the eighteenth national aeronautic meeting of the Society of Automotive Engineers, held in Chicago Aug. 26 to 28.

William B. Stout whose advocacy of all-metal airplanes startled the aeronautical world some years ago and later resulted in the development of the Ford all-metal trimotored plane, presented to the gathering of engineers a plea for original thinking and design in aircraft. Speaking on "The Possibilities of Radical Airplane Design," Mr. Stout explained his ideas on the advantages to be gained by original design along the lines not as yet undertaken.

* * *

Franklin Memorial Museum to Be Erected

A museum is to be erected in Philadelphia as a memorial to Benjamin Franklin, under the auspices of the Franklin institute and the Benjamin Franklin Memorial Inc. Plans call for a three-unit structure, comprising a memorial chamber housing a stature of Franklin, new quarters for the activities of the Franklin institute, and a large museum along the lines of the interesting Deutsches Museum of Munich.

The plan of making the intricate apparatus of science understandable to the layman is the underlying object of the museum. Exhibits for the most part will not carry the usual "do not touch" sign, but an invitation will be extended to see the exhibit work. In many cases the individual will be permitted to operate it himself. The project is being financed in part through the endowment of the Franklin institute and partly through popular subscription.

* * *

Publishes Technical Abstracts Booklet

Abstracts of scientific and technical publications from the Massachusetts Institute of Technology, Cambridge, Mass., have been published in booklet form by the institute. No. 5 of the series contains material from technical matter presented from July 1 to Dec. 31, 1929, while No. 6 covers the period from Jan. 1 to June 30, 1930. The material includes abstracts of doctors' thesis and covers mining and metallurgy, chemistry, biology and public health, physics, economics, mathematics, geology, and aeronautical, chemical, civil and sanitary, electrical, fuel and gas, mechanical, and naval architecture in addition to marine engineering subjects.

* * *

Model of Murray's Locomotive on Exhibit

The Museum of Peaceful Arts in New York has been made the recipient of a model of the first commercially successful locomotive designed and built by Matthew Murray, of Leeds, England. E. Kilburn Scott, prominent London mechanical engineer, is the donor. The locomotive started running in August 1812, on a railway between Leeds and Middleton, the roadbed for which was laid in 1758.

Murray's locomotives were the first to have two cylinders with cranks at right angles. They were complete with pump, feed tank, safety valve and other accessories for regular running. Due mainly to the rack rail the locomotive, although weighing but 5 tons, could haul 90 tons. Locomotives built by William Hedley, George Stephenson and Timothy Hackworth were subsequent to the advent of Murray's. Stephenson's first locomotive at Killingworth Colliery was a copy of his, and the "Rocket" was made in 1828, 16 years after Murray's locomotives had started regular daily service.

* * *

Boston Is to Get Metal Congress in 1931

The 1931 National Metal congress and exposition will be held in Boston, Sept. 21-25, according to a decision reached by the board of directors of the American Society for Steel Treating in a recent meeting. The exposition will be located in Commonwealth pier, as was the 1924 show when the society last convened in Boston.

PROFESSIONAL VIEWPOINTS

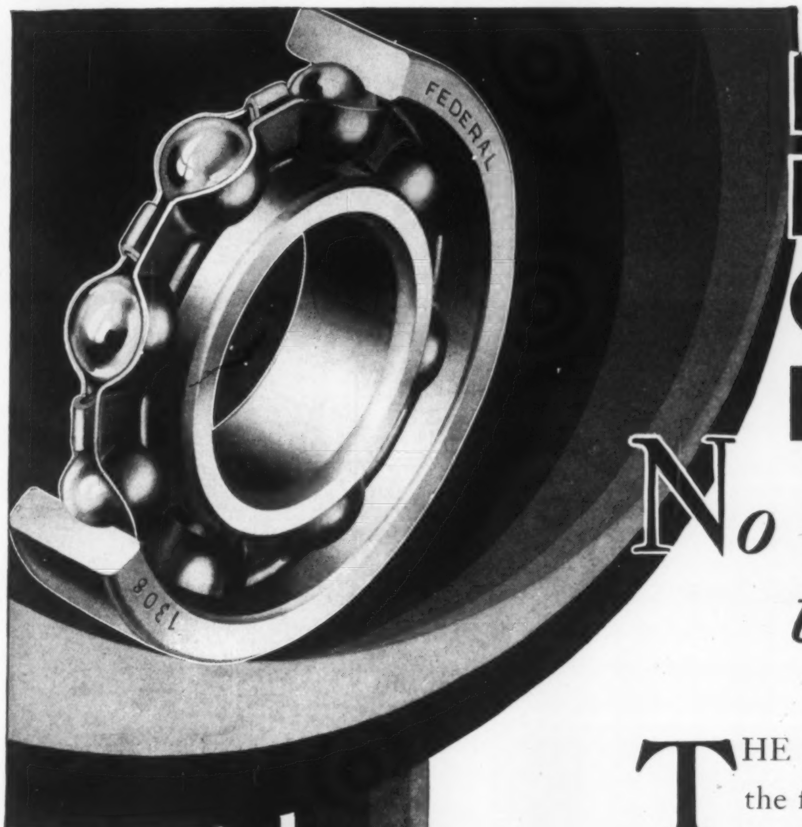
(*Concluded from Page* 51)

high pressure salesmen, as they were known.

Engineers as a whole have responded to the new order of things, but there still is far too large a number who have not yet learned to adapt themselves to the new order of the day. The biggest failure lies in the lack of appreciation of the necessity of outlining to the material sales engineer just what is required of the part for which material is under discussion. A mere detailed drawing will not and cannot suffice, for it merely provides an opportunity to check whether a given material will respond to the particular fabricating processes necessary to manufacture that part and tells nothing of loads, movements, shocks, wear, corrosion, exposure, etc.

The first and most essential step in the process of choosing the right material is to evaluate accurately all the properties desired of the material for the particular function. When this is correctly accomplished, the sales engineer then can play his part in recommending the proper material. It may seem an unnecessary and troublesome refinement to many, but it has the decided advantage that once done properly, it is an assurance of proper material choice at all times, no matter what the future holds in the development of new and special materials.

—JOHN F. HARDECKER,
Philadelphia



BETTER BEARINGS CANNOT BE HAD...

No matter what the price..

THE steel that goes into these bearings is the finest high carbon chrome steel. Each bearing is made with utmost care and precision. Every operation is checked. Every bearing part tested and calibrated. The most minute inspection follows every step in processing. The result is—a bearing of unusual quality giving better service and capable of sustaining the name and reputation of FEDERAL RADIAL BALL BEARINGS.

These are the reasons why we feel justified in making the statement that better bearings cannot be obtained, regardless of price!

The Mark of a Good Bearing

The Federal Bearings Company, Inc.
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Associated with
The Schatz Manufacturing Co.,
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Manufacturers of Commercial
Annular Ball Bearings

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FEDERAL

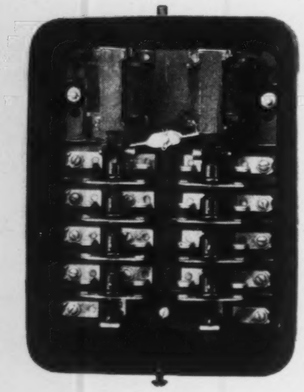
NEW MATERIALS AND PARTS

Worthy of Note by Those Engaged in the Design of Mechanisms or Machines

Switch Has Interlocked Contactors

REVERSING equipment for small motors, designated CR-7009-B-19, has been announced by General Electric Co., Schenectady, N. Y. This switch is designed to handle squirrel-cage motors rated 1½ horsepower at 110 volts, and 2 horsepower at 220, 440, 550 and 600 volts, 25 to 60 cycles.

The switch consists of two contactors, mechanically interlocked and having four sets of contacts and terminals. Three of these contact sets are for power circuits and the remaining one is for the holding circuit of the coil. Terminals are front connected and are marked to facilitate wiring.



Interior of switch for small motors, showing contact sets mounted on a compound base. Cover is removable

Equipment is mounted on a compound base for mounting in an enclosing case. The case is suitable for wall mounting and has removable cover and knockouts for the incoming and outgoing leads. A three-button ("forward" "reverse" "stop") push-button station is recommended for a control switch.

Metal Substitute Is Copper Alloy

A SUBSTITUTE for phosphor bronze, manganese bronze and gun metal, known as P. M. G. metal developed by Vickers-Armstrong Ltd., Barrow-in-Furness, England, is now available in this country through the Driver-Harris Co., Harrison, N. J. The new metal is hardened copper alloy in which the 10 per cent tin is replaced by 10 per cent of a special hardener. It is especially suitable for use where high tension strength, considerable elongation and resistance to abrasion are required.

Perform Time Cycles Automatically

CONTACTORS to perform operations on a time cycle basis are coming into greater use for such work as the automatic operation of furnace doors, automatically advancing the load in a continuous type furnace, automatic lubrication, automatic operation of hydraulic presses used in the process of plastic molding of bakelite, hard rubber, etc. New units of this type recently were announced by Automatic Temperature Control Co. Inc., Philadelphia.

Fig. 1 shows a cycle stop type contactor designed to handle three contacts per cycle in desired sequence. Accurate timing and necessary power for operation is obtained from a small synchronous motor, geared to desired time of cycle. Change gears permit altering time of cycle. One cam is pinned to the cam shaft, but the others are held in spring tension and are in adjustable relation to each other within the time of the cycle. Provision is made for shortening or lengthening the time of contact per cycle, and where necessary, contacts can be provided of a type to quickly make and also

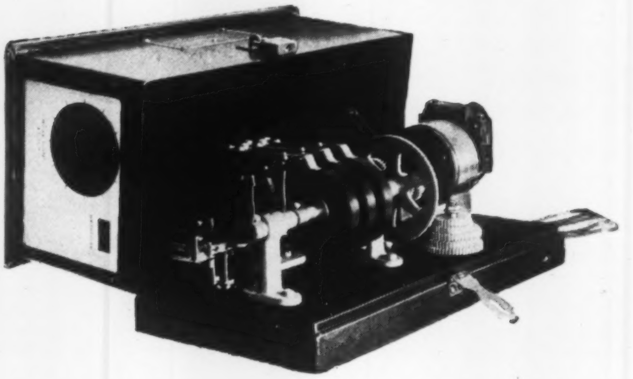
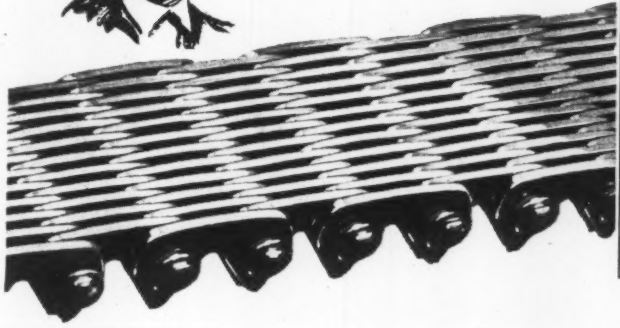
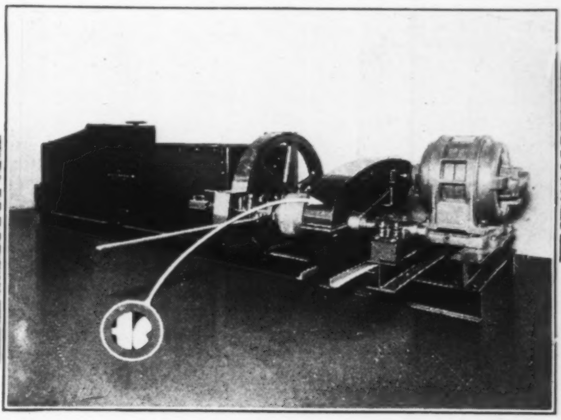


Fig. 1—Cycle stop unit which handles three contacts per cycle in sequence

Let the MORSE ENGINEER Analyze Your Present POWER TRANSMISSION





Lancaster No. 45 Pug Mill with self contained Morse Drive and Motor Attachment

WHEN generated power is wasted through slippage and friction, or when expensive power transmission break downs occur, call in the Morse Engineer for a consultation. His job is to know power transmission methods, and the remedy for wasteful equipment. He will recommend the simplest, easiest, and least costly way to obtain smooth, efficient, profit-making operation.

Many firms who have called in Morse Engineers have found that the slight changes recommended have resulted in a complete reversal of plant conditions. One prominent manufacturer says "Morse Silent Chain Drives were installed on our rolling mills in the summer of 1928, and have operated 10 hours a day since without the slightest trouble".

Call in the Morse Engineer. Send for the free Morse Power Transmission data file which contains interesting facts and figures pertaining to your business.

MORSE CHAIN CO., ITHACA, N. Y.
Manufacturers of Morse Silent Chain Drives,
Flexible Couplings and Chain Speed Reducers
BRANCHES IN PRINCIPAL CITIES

MORSE SILENT CHAIN DRIVES

quickly break their circuit. Progress of the cycle is shown by an indicator arm which travels around a graduated dial marked on a glass in one end of the instrument case. The number of operations in a given time readily may be noted as a totaling counter is tripped each cycle.

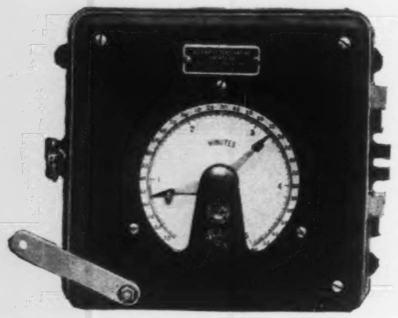


Fig. 2 — Cycle stop type contactor in which change of time cycle is made by adjusting knob

Units of this type have been built with eleven contact disks and with a cycle of 96 hours, while others have been built with a cycle of only a few seconds.

Fig. 2 shows a cycle stop type contactor which does not require change gears to alter the time of cycle, this change being easily and quickly made by means of an adjusting knob outside of the instrument case. The zero adjusting screw permits accurately setting the lower contact while the adjusting knob mentioned above is used to set the upper contact for any desired elapsed time within the dial range of the unit. Motive power and means for accurate timing are obtained from a small double field synchronous motor, which moves the elapsed time contact arm clockwise or counter-clockwise, depending on which of its field coils are energized. This unit is built in both the cycle stop and the cycle repeating types.

Oil Pump Provides High Pressures

FOR hydraulic transmission of power, Tuthill Pump Co., Chicago, has announced a model H high pressure oil pump. Sizes range in capacity from 10 to 40 gallons per minute against a pressure of 1000 pounds per square inch. Flange mounting provides a means of connecting the pump directly to the gear housing or the end flange of a motor. An angle pedestal for foot mounting also is available.

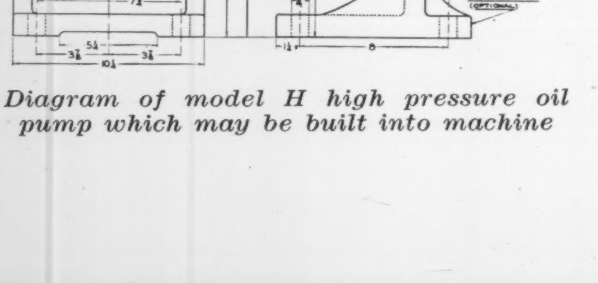
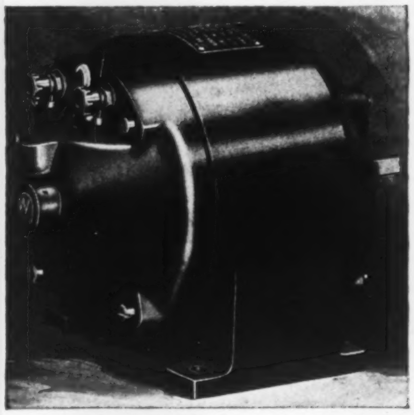


Diagram of model H high pressure oil pump which may be built into machine

Model H also is provided with an adapter flange for both intake and discharge ports, thus allowing for use of the manifold design best suited to each individual installation, or for a manifold with a relief valve incorporated in its design. Uses include the machine tool field, hydraulic feeds, where hydraulic operation of various mechanisms is employed, and in the refinery field where booster pumps are required in handling oils. Model H can be driven at direct motor speed up to 1200 revolutions per minute.

Motor Starting Current Constant

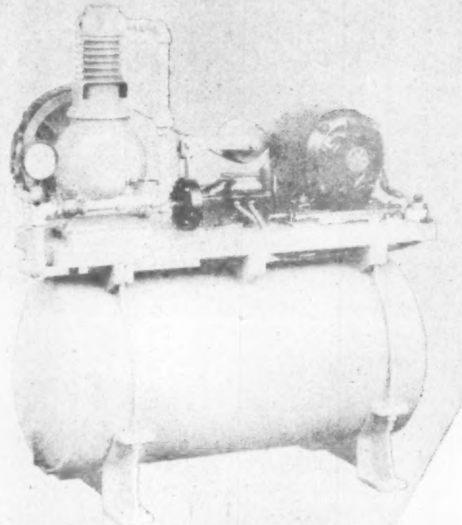
A NEW high starting torque, ¼ horsepower, 1725 revolutions per minute split phase motor, identified as the type CAH clutch motor, has been announced by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The starting current is constant regardless of the load, making it especially suitable for driving small machines which are sold for operation on 110 volt lighting circuits.

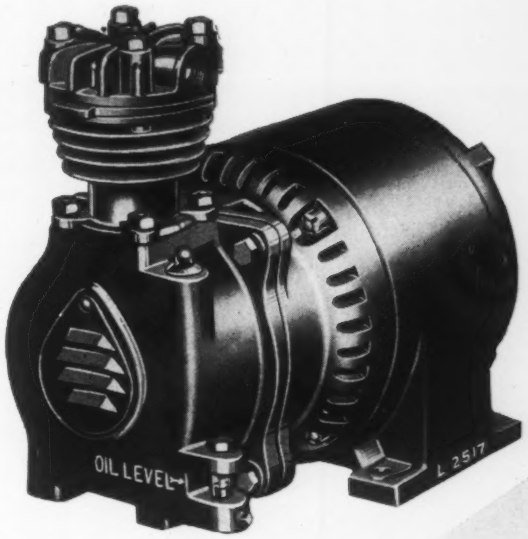

High starting torque, split phase motor equipped with clutch mechanism of special design

Design of the clutch mechanism, which gives the motor the high starting torque, makes it possible to start heavy loads. Under normal conditions, the motor carries the load up to speed in the same manner as an ordinary split phase motor. However, in cases where the load is stiff, or is difficult to start because of thick oil or compression as in the case of pumps or compressors, the motor delivers a series of power impulses that tend to overcome the static friction and inertia of the load, and bring it up to

THE OLD GIVES WAY TO THE NEW

Modern Principles Guide the Application of Motor to Machine





Established on the principle that the motor and the machine which it drives should be designed to fit each other in an attractive, efficient unit, the Product Engineering Division of The Master Electric Company is prepared to cooperate with manufacturers' engineers in the solution of *special* problems in motor application.

When the motor is built with due regard for the machine of which it is to become a part, and the machine is designed to receive that motor—refinements are very often possible, which produce distinct advantages over the result when the motor was "added on" haphazardly.

Our experience has shown that one or more of the following benefits are realized as the result of re-design, treating the machine and the motor as related parts of a complete unit:

Production cost is reduced by the elimination of belts, gears and other parts.

Better over-all efficiency is obtained, with a resultant lowering of operating cost.

Appearance is enhanced by proper design.

The manufacturer retains control of the type and style of motor on his machine, assuring him his profit on the sale of the motor.

The creating and building of a "Special" motor is not necessarily costly. The Master Electric Company is in an excellent position not only to design a "Power Diamond" especially for your product, but to build it on a quantity production basis at a moderate cost. Write for information.

THE MASTER ELECTRIC COMPANY
DAYTON, OHIO

The POWER DIAMOND

STOCKS CARRIED IN PRINCIPAL CITIES

MORE THAN 100 SERVICE STATIONS

MASTER GUARANTEED MOTORS

1/30 TO 10 H.P.

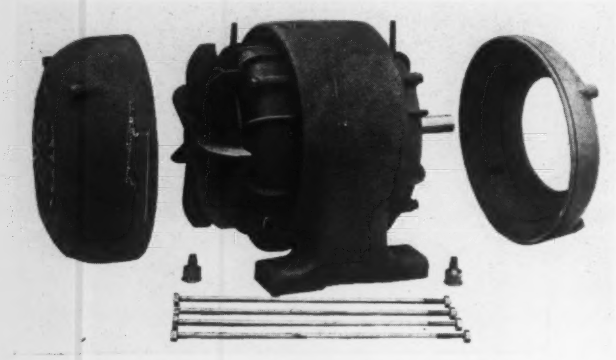
Dayton
THE
MASTER
ELECTRIC CO.
Ohio

Not More Than 40°

speed. These power impulses increase until the load is started, or until approximately 680 per cent full load torque is developed.

New Motor Completely Enclosed

COMPLETE enclosure of the winding, air gap, rotor and bearings by a cast iron inner case is a feature of the "Klosed-Tite" motor recently announced by Sterling Electric Motors Inc., Los Angeles. The unit can easily be disassembled. Inner enclosing cases have air directing veins and large radiating spaces.



Disassembled view of enclosed motor showing inner and outer cases, fan, etc.

Sealed leads are not disturbed by disassembling the motor and windings are insulated by the "Sterling Mica-Bestos" process. The unit is particularly advantageous for installations where ferrous dust is present, such as in foundries, chemical plants, etc. "Cros-Line" starting and ball bearings are other features. No compensators or current reducing starters are necessary to operate this fan cooled motor.

Coating Alloyed With Base Metal

NEW uses for sheet steel and developments of older uses have brought forth a demand for better coated stock. To meet these requirements Inland Steel Co., Chicago, has introduced Gal-Van alloy, a new coated steel sheet having no separate layer of pure zinc. The coating is completely alloyed with the base metal by a special process.

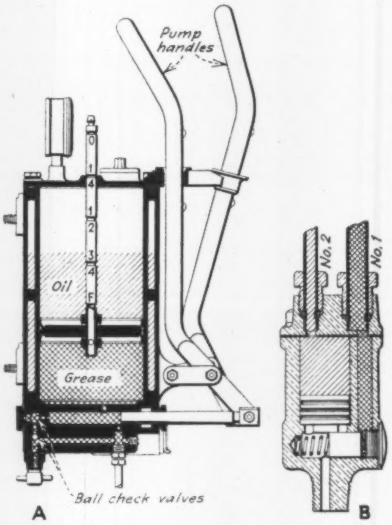
Adaptable for many forming operations, this new product withstands severe fabrication, drawing or double seaming, without flaking or cracking of the coating. It is a coated sheet with a smooth, but not a slick surface and consequently finishes such as paint and enamel adhere readily and firmly, usually without the necessity of using an etching solution. Gages range from 16 to 30 inclusive and in two grades.

Develops Lubricant Distributor

TO PROVIDE a positive lubrication means for distribution of heavy-duty compounds and mill greases, Lubrication Devices Inc., Battle Creek, Mich., has developed the Farvel Dualine system. It consists of a central compressor shown in the accompanying illustration, and two main supply lines connected in series to a positive piston displacement type of measuring valve located at each bearing.

One line delivers the heavy grease to all valves, filling each with a measured quantity from the central station. The other supply line is connected to each valve from the central station and is used to discharge lubricant from the valve into its bearing. A double compartment reservoir serving two individual plunger-type guns comprises the central pumping station. One gun delivers the grease to the valves while the other provides the necessary pressure to discharge the valves. The level of the fluid in the oil compartment is indicated by a float gage.

Filling of the grease chamber is accomplished through a connection at the base. In use the grease pump is operated until a pressure of 1000 pounds registers on the gage, which indicates that all valves have been filled. Then the oil pump is operated until the gage shows 1000 pounds pressure, indicating that all valves have discharged grease into the bearings.



Central compressor of lubricating system is shown at A. B is the valve which is fully automatic

Speed Changer Remote Controlled

ELECTRICAL push button control recently arranged for the "JFS" type of variable speed transmission now enables operators to increase or decrease drive speeds without leaving their desks. The change is made by merely

(Concluded on Page 72)

Giving Your Product Colorful Sales Appeal

◆ ◆ AT LOW COST

Carnation
MALTED MILK

Carnation
MALTED MILK

White Vitreous enameled seamless drawn steel Malted Milk Dispensing Jar . . . with colored decalcomania burnt into the enamel . . . and a nickel-silver seamless drawn cover.

G. P. & F. Can Show You How To Do It . . . .

THROUGH the use of pressed metals old products as well as new ones are emerging over night in polychromatic splendor . . . . and winning public favor. Many manufacturers are securing this added sales appeal of color at low cost by using G. P. & F. stampings.

Whether it's a smooth satiny finish or a brilliant gloss you desire for your product, it can be imposed on metal "right off the press".

The 19-acre G.P.&F. plant is equipped with every known facility for producing quality stampings at low cost: Each G.P.&F. drawn or pressed metal part has a smooth surface which provides a finishing base permitting quick and economical application of paint, lacquer and other modern finishes.

Likewise in problems of design or redesign, G.P.&F. can save you time and money. With a background of fifty years' experience G.P.&F. engineers have been able to assist thousands of manufacturers in cutting down designing time and speeding new or improved products to the market.

Whether your problem is one of design, color application, better service or lower production cost, consult G.P.&F. There is no obligation.

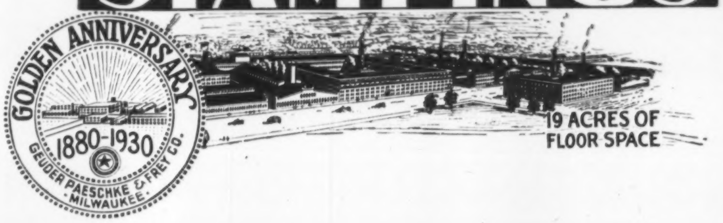
GEUDER, PAESCHKE & FREY CO.

Sales Representatives in Principal Cities in All Parts of the Country

1389 St. Paul Avenue, Milwaukee, Wis.
364 W. Ohio Street, Chicago, Ill.

G.P.&F.

STAMPINGS



GEUDER, PAESCHKE & FREY CO.

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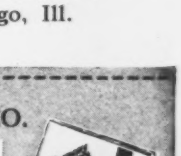
364 W. Ohio St., Chicago, Ill.

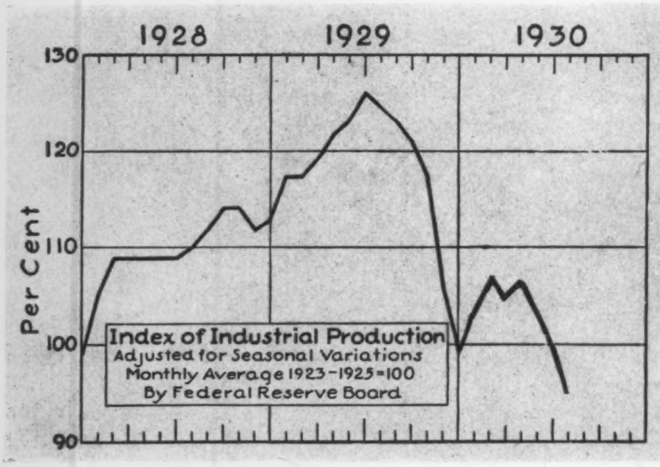

In Harmony with Modern Progress

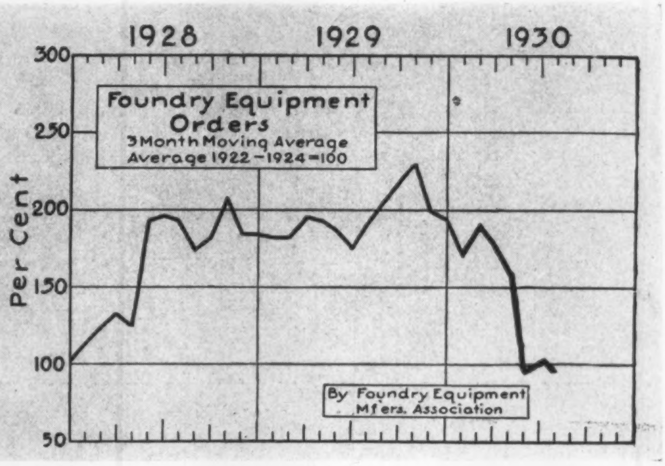
Please send your 1930 Booklet, "In Harmony with Modern Progress," to the address below. It is understood the writer is not obligated.

*Name*________________________

*Company Name*________________________

*Address*________________________



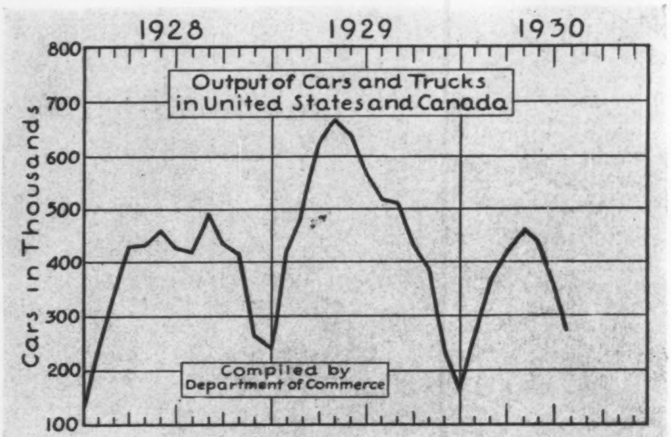


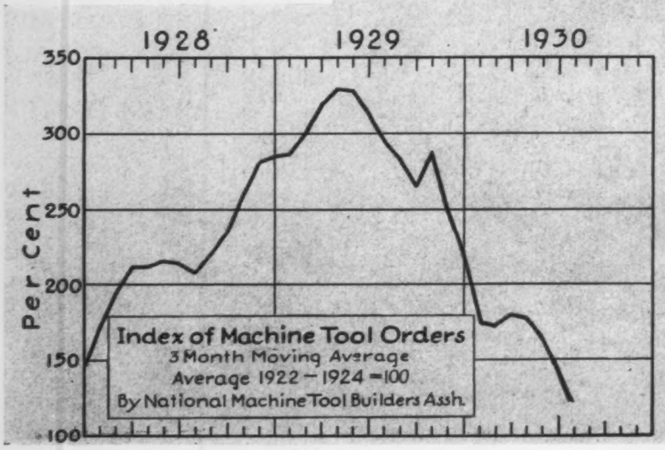
HOW IS BUSINESS?

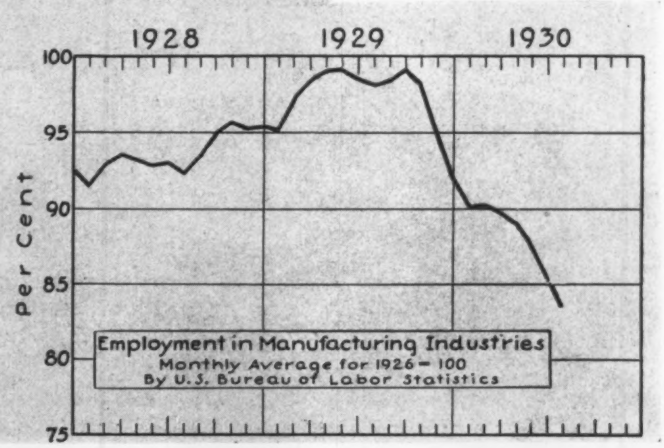
ALTHOUGH a degree of uncertainty still prevails to retard business recovery, there is an improvement in sentiment. With the drought broken, bringing relief to stricken areas, farm equipment manufacturers look favorably upon the present situation. Signs of small inconsequential gains in some phases of business appeared late in August.

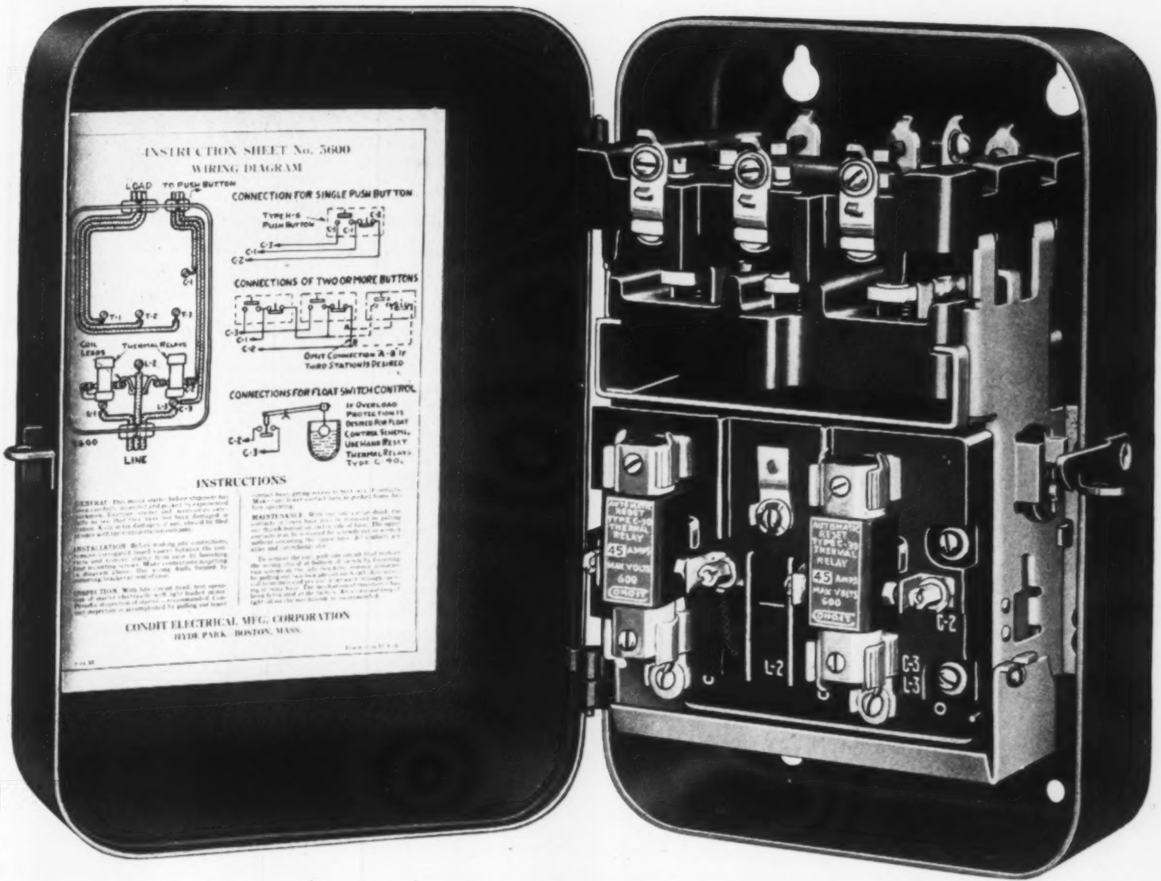
The automobile industry was expected to take a decided turn upward but current operations indicate that business cannot look to this department as a leading consumer. In the foundry industry St. Louis reports heavier orders for those companies specializing in tractor and automotive castings. Aside, however, from road building maintenance machinery, which continues active, business among machinery and engine manufacturers is not particularly impressive. Steel mill equipment manufacturers in the Pittsburgh territory have had a busy first half and now are looking favorably upon the remainder of the year. Rolls, however, have been poor sellers due to light operations in the finishing mills.

Industrial production in July dropped to the lowest point for any month in six years, according to the federal reserve board's index. Exports of electrical equipment from the United States during June declined $676,817, compared with the value of exports in the corresponding month a year ago. An upward tendency in a number of indices of commodity prices, strengthens the belief that the turning point for commodities is near.








INSTRUCTION SHEET No. 5600
WIRING DIAGRAM
LOAD
TO PUSH BUTTON
CONNECTION FOR SINGLE PUSH BUTTON
TYPE H-6 PUSH BUTTON
CONNECTIONS OF TWO OR MORE BUTTONS
OMIT CONNECTION 'A-B' IF THIRD STATION IS DESIRED
CONNECTIONS FOR FLOAT SWITCH CONTROL
IF OVERLOAD PROTECTION IS DESIRED FOR FLOAT CONTROL SCHEME, USE HAND RESET THERMAL RELAYS TYPE C-40.
COIL LEADS
THERMAL RELAYS
LINE
INSTRUCTIONS
CONDIT ELECTRICAL MFG. CORPORATION
HYDE PARK—BOSTON, MASS.
AUTOMATIC RESET TYPE C-30 THERMAL RELAY
45 AMPS
MAX VOLTS 600
CONDIT
L-2
C-2
C-3
L-3

HARDLY AN ARC ONLY A SPARK

7 INSPECTIONS

at seven different definite steps in its manufacture, and a final test to determine that it operates correctly at its highest rated capacity, assure you of the complete safety and dependable performance of the A-30 air motor starter. It is made with the precision of a fine instrument, by machinery especially designed for its production. By preventing the arc from forming, rather than by extinguishing it after it has formed, it eliminates gas and minimizes contact burning. You will find it in every way a desirable and profitable installation, accessible, simple, compact and economical.

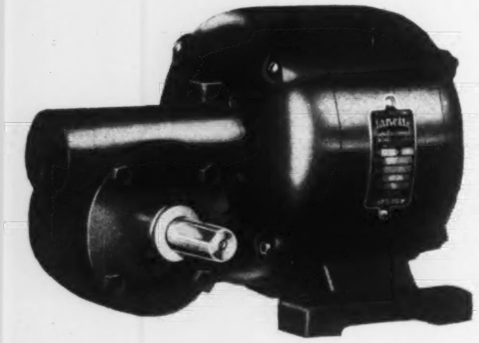
Write today for Bulletin.

"Get in touch with Condit"

CONDIT ELECTRICAL MFG. CORPORATION
Boston, Massachusetts, U. S. A.

CONDIT

Compact Motor
And Speed Reducer
In One Unit!



JANETTE
Motorized
SPEED REDUCERS

The Janette Motorized Speed Reducer combines a motor and a Speed Reducer in one compact unit, making a highly satisfactory slow speed drive assembly.

Its compactness makes possible a neat, more machine-like design on equipment which it operates.

This unit is equipped with a ball bearing Janette Motor—a motor of higher quality—and reducer of worm-and-gear type, quiet in operation, made quieter yet by running in a bath of oil. 1/30 to 1/3 h.p. Ratios: 20 to 1 to 100 to 1.

Write for Bulletin SR-529

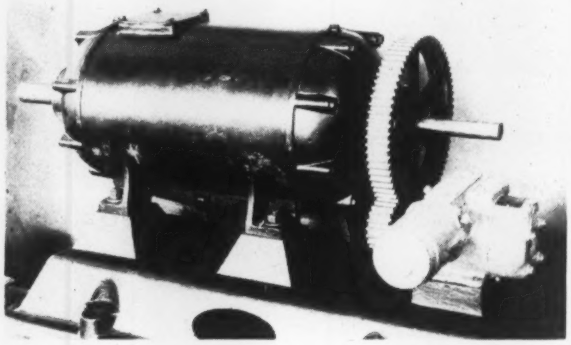
JANETTE MANUFACTURING CO.
558 West Monroe Street, Chicago
Singer Bldg., 149 Broadway
New York
Harrison Sales Co.
314 9th Ave. N.
Seattle, Wash.
Real Estate Trust Bldg.
Philadelphia

NEW MATERIALS AND PARTS

(Concluded from Page 68)

pushing one of two buttons until the required speed is reached. The "JFS" variable speed transmission which recently was developed by Stephens-Adamson Co., Aurora, Ill., is an enclosed unit. When driven by a constant speed electric motor or other power source it will deliver the power at a greatly reduced speed that can be changed to suit the machine being driven.

Ordinarily the speed is controlled by turning a handwheel. Where the drive is accessible, this method is entirely satisfactory, but when the drive must be located overhead or in a crowded corner the control often becomes difficult. In several recent installations the electrical remote control has been used with the pushbuttons located at a considerable distance from the drive. In each case, the usual control wheel on the transmission was replaced by a spur gear driven forward or backward by means of a compact C-H control motor mounted on the base. One or more pushbutton boxes were placed at any distance from the machine and the speed increased or decreased by pushing the "fast" or "slow" button.



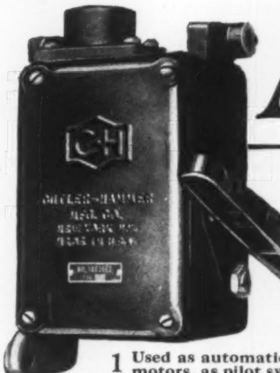
Variable speed transmission equipped with remote control

As long as one button is pressed, the "JFS" speed changer steadily increases or decreases its output speed. When the desired speed is reached, the button is released and the rotation remains constant until a new speed is needed. When the control buttons are located out of sight of the drive, a tachometer can be used to indicate the exact speed of the machine in either number of revolutions, feet per minute or the number of units being produced per hour.

New Drive Employs Endless V-Belts

DEVELOPMENT of a multi-V belt drive in conjunction with the Goodyear Tire & Rubber Co., Akron, O., has been announced by the

Above all, pressure and float switches must be dependable



C-H Enclosed
Float Switches
for A. C.
or D. C.
Service

(Bulletin 10036)

1. Used as automatic starter on small motors, as pilot switch to starter on larger motors.
2. Quick make and quick break reduce arcing and prolong life of contacts. Cam and roller type, maintaining constant pressure until switch opens. Heavy contacts to withstand severe service.
3. Standard C-H finger construction designed for long life, requiring minimum care. Easily renewable.
4. Switch easily changed for tank or pump operation.
5. Cast iron enclosing safety case, dust- and splashproof. Conduit holes provided at top. Interior made easily accessible for test, inspection and adjustment by removing 4 screws from cover.
6. All parts conform to C-H Standard of ruggedness.

PRESSURE and float switches often take the place of human watchers; sometimes they are entrusted with the responsibility for vital production operations; since they "control the control" they should match the rest of the electrical equipment in dependability and efficiency of operation. Otherwise you are exposing production to needless delay, loss and expense.

Cutler-Hammer pressure and float switches have kept pace with Cutler-Hammer Motor Control in their development. You will find in them the same advanced design, the same high-grade workmanship, the same exacting standards of performance.

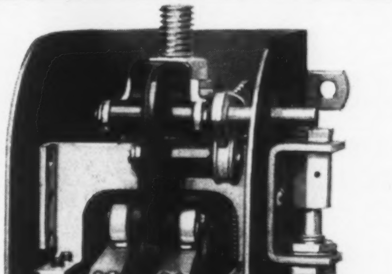
Those shown on this page are illustrative of the entire comprehensive line, of the compactness and correctness of design of C-H pressure switches in general. Complete information as to these or switches for any purpose you may have in mind will be sent upon request.

CUTLER-HAMMER, Inc.
Pioneer Manufacturers of Electric Control Apparatus
1320 St. Paul Avenue
MILWAUKEE, WISCONSIN

THE CUTLER-HAMMER INC.

C-H Enclosed Pressure Regulator
for A. C. or D. C. Service
(Bulletin 10014)

1. Stationary contacts are adjustable with calibrated scale to give any desired operating pressure.
2. Bourdon tube actuates visible indicating needle—also actuates swinging contact arm which in turn controls motor-operation.
3. Long operating life assured by having swinging arm handle only pilot circuit of relay while relay handles pilot circuit of motor starter.
4. Gauge type for vacuum, pressure or hydraulic applications.
5. Full automatic operation. Easy installation.
6. Accurate adjustment—uniform operation.
7. For either standard or reverse operation.
8. Both swinging arm and relay have silver contacts which insure good contacts under all conditions.
9. Sturdy dustproof safety enclosing case provided with conduit knockouts at sides and bottom. Threaded pipe connection to Bourdon tube.
10. Standard C-H sturdy and simple construction.



New C-H Pressure Switch
(Bulletin 10006)

Quick *double* break, and make, sturdy simple construction add dependability to pumping and compressor equipment.

1. *Double*-break contacts reduce arcing. Silver tips increase current-carrying capacity. Long life assured regardless of frequency of operation.
2. Two connections complete the wiring. Ample wiring space. Knockouts provided for conduit or armored cable wiring.
3. Rubber diaphragm and tension spring control switching mechanism without strain. Minimum moving parts, simple design, assure uniform, long-life operation.
4. Unloader—for air compressor service. Automatic movement releases valve and unloads back pressure from compressor, making starting of motor easy.
5. Sturdy, black japanned enclosing case. All metal parts cadmium plated and corrosion-proof. One hand-screw allows removal of cover, for adjustment or inspection.

CUTLER HAMMER

C-H

The Control Equipment Good Electric Motors Deserve

(A-287)

RARE METALS AND ALLOYS

TANTALUM · TUNGSTEN · MOLYBDENUM · CAESIUM · RUBIDIUM

RUBIDIUM · CAESIUM · MOLYBDENUM · TUNGSTEN · TANTALUM

FANSTEEL

for

Contact Points

Uniform
Grain
Structure

Assures
dependable performance

WHEN you buy contact points, specify the type that will wear *evenly,* if they wear at all, always keeping a clean, smooth contact surface, free from pitting or burning.

In Fansteel Contact Points, long life, dependable performance and a very minimum of attention are assured because they are made from 99.95% pure Tungsten or Molybdenum, refined in the Fansteel plant under strict laboratory control.

Each lot of metal is carefully examined for grain structure and compared with laboratory standards, only perfect metal being made into contact points. Being cut from rods instead of stamped from sheets, Fansteel Contacts have *end grain metal* for a wearing surface.

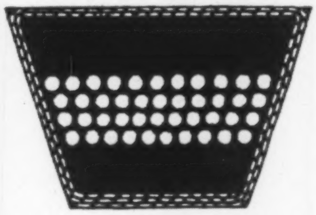
Turn your entire electrical contact question over to Fansteel, who will recommend the correct points to use, designing them specially if necessary, and manufacturing them for you as well.

**FANSTEEL PRODUCTS
COMPANY, Inc.**

NORTH CHICAGO, ILLINOIS

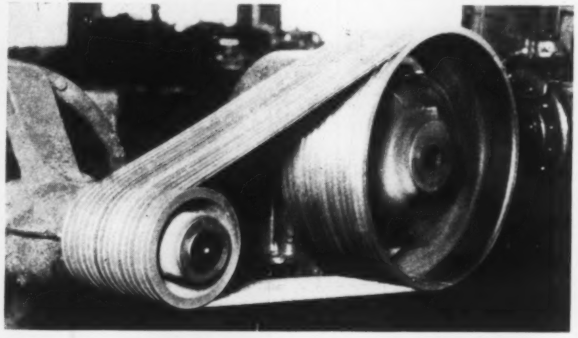
Worthington Pump & Machinery Co., Harrison, N. J. The drive consists of a number of endless molded V-belts running in V-grooved sheaves. It combines a rubberized cord V-belt impervious to dust and moisture, with an improved V-grooved sheave.

High power capacity, long flexing life, low stretch, accurate cross section and high quality rubber are claimed for the Goodyear Emerald belt. The load carrying members are high grade cotton cords arranged in parallel lines and concentrated about the neutral axis. Each belt takes an equal share of the transmitted load. Sheaves are carefully grooved and finished so that each groove affords a smooth surface on which the belts run.



Cross section of Goodyear V-belt showing construction including cord center and elastic envelope

Wedging action between grooves and belts results in a slipless powerful grip, without binding or backlash, which is said to transmit about 99 per cent of the applied power at high speed ratios, over short centers without idlers. When a V-belt is flexed over the pulleys, the outside half of the thickness is under tension while the inside half is under compression, it is asserted.



Multi-V-Belt drive combines a new rubberized cord belt with improved sheave

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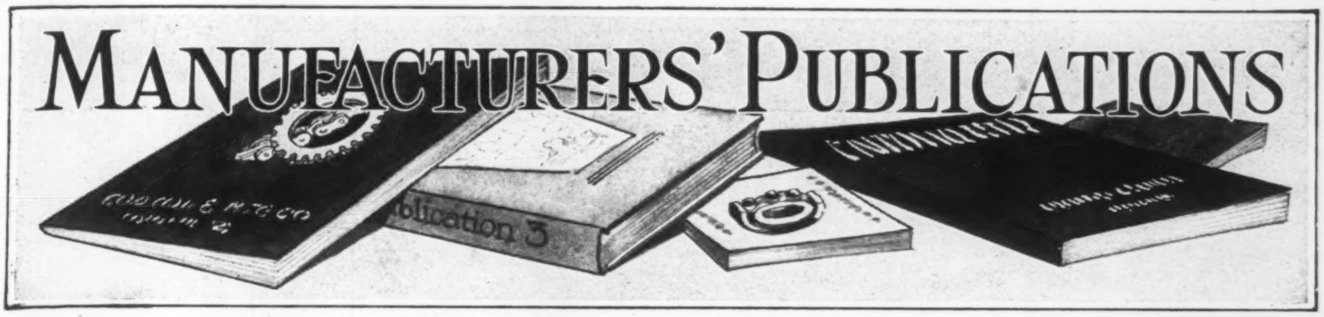
DURING the past eight years the Aluminum Co. of America has been developing an alloy for internal combustion engine pistons which combines light weight, low coefficient of expansion, high thermal conductivity and good bearing properties. As a result they are now marketing an alloy of aluminum, nickel, copper and magnesium under the trade name "Lo-Ex."

MANUFACTURERS' PUBLICATIONS



Publications listed in this section may be obtained without charge from the manufacturers of the products or through MACHINE DESIGN

ALLOY STEEL—Resistance of Nirosta KA2 and KA4 against chemical attack is discussed in a recent issue of the technical bulletin series published by Associated Alloy Steel Co. Inc., Cleveland. Tables showing the results of tests are shown throughout the 15-page booklet which contains much interesting data.

INDUCTION MOTORS—Reliance Electric & Engineering Co., Cleveland, has published a bulletin on its fully enclosed fan-cooled induction motors with ball bearings. Details of construction and engineering data are included.

CENTRIFUGAL PUMPS—Pennsylvania Pump & Compressor Co., Easton, Pa., is distributing a bulletin on its double suction, single stage centrifugal pumps, with ample illustrations and full description of construction and operation.

LOADING CHAIN—High strength with minimum weight is claimed for its loading chain in a leaflet by the American Chain Co. Inc., Bridgeport, Conn. Specifications are given.

SPROCKETS AND CHAIN—Cullman Wheel Co., Chicago, has issued a handbook on sprockets and sprocket chain and their uses. It describes many types of these devices and contains much pertinent information on the subject.

VALVES—Benefits of metallurgical control in the production of better valves is made the subject of a bulletin by the Edward Valve & Mfg. Co., East Chicago, Ind. These are especially noticeable in valves used for high pressure and high temperature.

SCREW CONVEYOR DRIVES—Link-Belt Co., Chicago, has compiled a book describing its line of Caldwell screw conveyor drives built by H. W. Caldwell & Son Co., Chicago, a subsidiary. Illustrations show the drives and typical installations. Engineering data are appended, enabling selection of the most suitable drive for a given installation.

LUBRICATION—Roberts Lubrication Equipment Co. Inc., 705 Wabash building, Pittsburgh, describes in a booklet its provision for meeting the varied problems of lubricating machinery in steel mills by its centralized systems of positive pressure application. Equipment is illustrated and the text describes methods of applying lubricant to various kinds of mill machinery. Problems in lubrication are discussed and solutions suggested.

SPEED REDUCERS—Philadelphia Gear Works, 1129 Vine street, Philadelphia, has issued a catalog of its speed reducing units, 120 pages, illustrated.

ELECTRIC MOTORS—Wagner Electric Corp., St. Louis, has published a bulletin on its motors, discussing power factor and its correction, with curves and illustrations. Construction details and applications of the motor are covered. Control equipment is described.

REMOTE CONTROL—Brown Instrument Co., Philadelphia, in a current bulletin describes and discusses the de Florez system of remote manual control handled by the company. Illustrations show the mechanism and diagrams explain its operation.

CASTING CHART—William J. Sweet Foundry Co., division of the Industrial Alloy Products Co., 8 Lister avenue, Newark, N. J., has prepared a revised chart of its range of chrome iron and chrome nickel iron alloys for corrosion and heat resistance, giving late information on applications of each. The chart also explains results from a new method of castings practice to obtain stainless steel castings suitable for polished surfaces.

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MEN OF MACHINES

(*Concluded from Page 58*)

1924 with a master of science degree and after a year at Purdue university he became director of research for the Lincoln Electric Co., Cleveland.

* * *

W. W. Slaght, until recently chassis experimental engineer, Pierce-Arrow Motor Car Co., Buffalo, now is chief engineer, Cleveland Steel Products Co., Cleveland.

* * *

Frank L. Eidmann has resigned as associate professor in the Princeton school of engineering to become professor of mechanical engineering at Columbia university, New York.

* * *

G. John Gruber, formerly centrifugal pump engineer with the Babcock-Wilcox & Goldie-McCulloch Co., Galt, Ont., recently was appointed chief designer for Yeomans Bros. Co., Chicago.

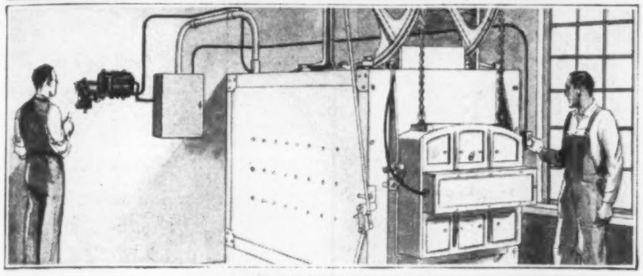
Obituaries

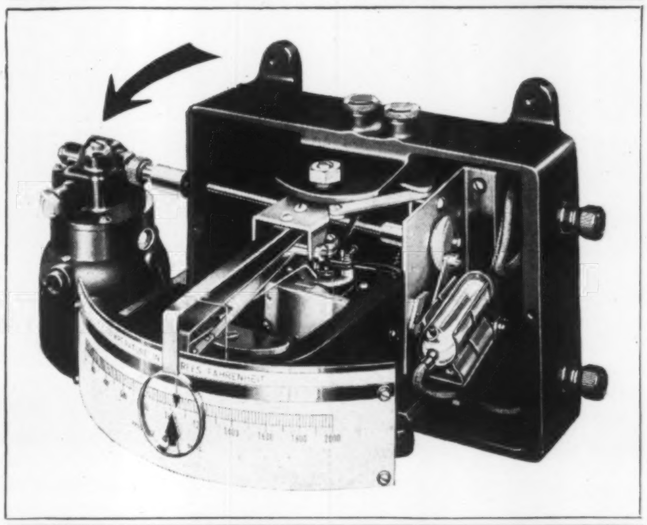
DR. IRA N. HOLLIS, 74, president from 1913 to 1925 of Worcester Polytechnic institute, Worcester, Mass., and president in 1917 and latterly honorary member of American Society of Mechanical Engineers, died Aug. 15 at his home in Cambridge, Mass., of a heart attack. During the World war Dr. Hollis served on the fuel conservation committee for Massachusetts and as chairman of the committee for public safety in Worcester. He was born at Mooresville, Ind., in 1856, and was graduated from United States naval academy in 1878. He served as an engineer in the navy until 1893, when he resigned to become professor of engineering at Harvard university. He remained until 1913, resigning to become president of Worcester Polytechnic institute.

* * *

Arthur S. Holmes, designer of special machinery, and president of the Holmes Engineering Co., Oshkosh, Wis., died recently, following a heart attack. He was 55 years of age. From 1914 to 1929 he was vice president and sales manager of the Green Bay Drop Forge Co., Green Bay, Wis., and designed a line of high-production, semiautomatic machines for the automobile industry, resigning Jan. 1, 1929, to devote his entire time to the Holmes Engineering Co., designing and building special machinery.

▲ ▲ ▲ HOW BODINE MOTORS SERVE REPUBLIC CONTROL PYROMETERS





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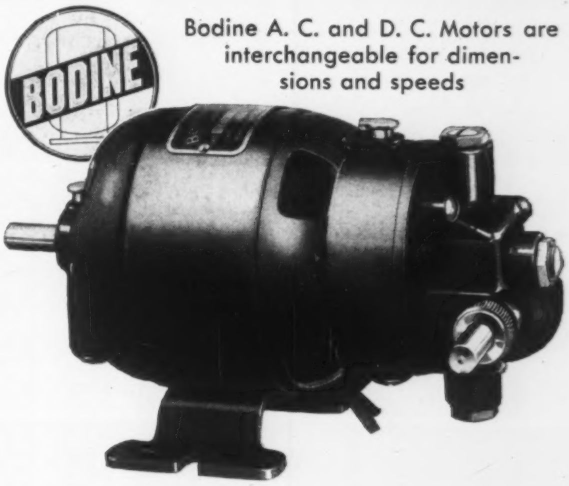

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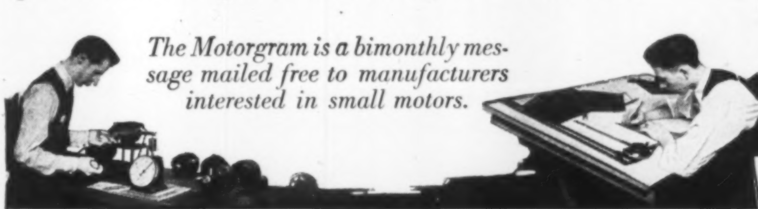

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